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IN THIS ISSUE:

THE CULTIVATION OF INTRODUCED PASTURE PLANTS

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NOTES ON ANIMAL DISEASES

PASTURE MANAGEMENT

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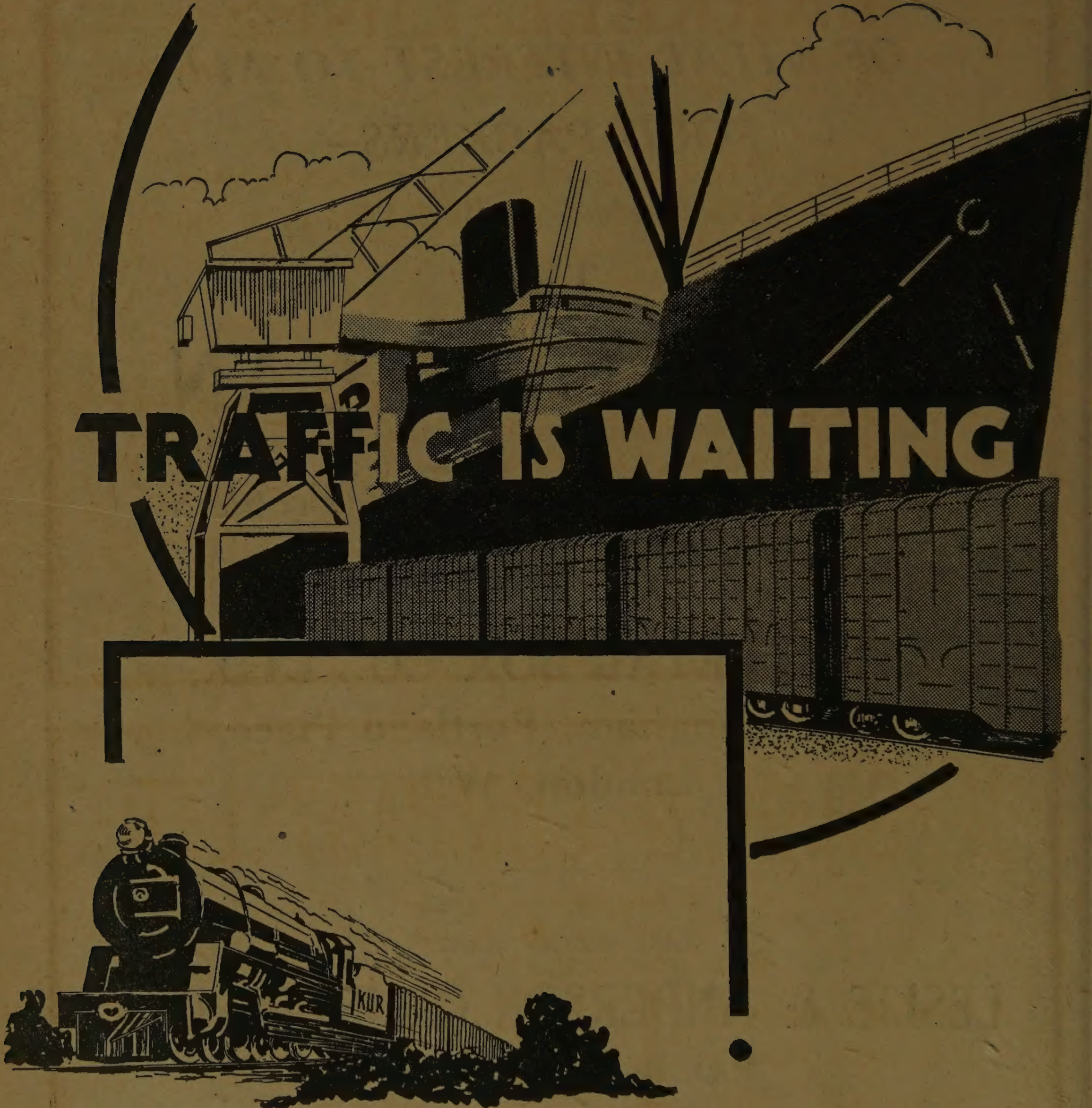

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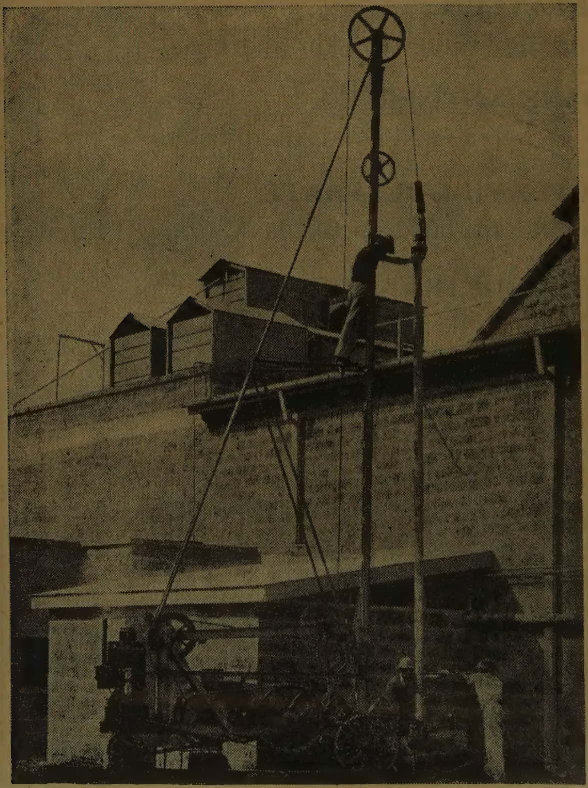

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the *Journal* or not, should be addressed to the local Director of Agriculture, and not to Amani.

CONTENTS

PAGE
E.A.A.F.R.O. 1
Corrigenda 2
The Cultivation of Introduced Pasture Plants (H. J. van Rensburg) 3
Ascochyta Blight of Cotton (Maud M. Wallace) 10
Tests of Insecticides on Cattle (P. R. Wilkinson) 12
Notes on Animal Diseases 18
Further Note on Onion Experiments on Kilimanjaro (R. J. M. Swynnerton) 23
Pasture Management (H. J. van Rensburg) .. 26
Soil Phosphates—A Review of the Literature (H. F. Birch) 29
Applied Hydroponics (Extract from *The Fertilizer Journal*) 33
Bacterial Soft Rot of Vegetables (G. B. Wallace) 34
Fertilizers and Leys (Extract from *The Fertilizer*) 35
A Note on the Deterioriation of the Toxic Content of Separated Pyrethrum Achenes Compared with that of Whole Flowers (J. Hopkins) 36
The Effect of Seed Treatments, Nursery Technique and Storage Methods on the Germination of Tung Seed (C. C. Webster) .. 38
Tropical Grapes 48
Report on a Trial with D.D.T. and B.H.C. for the Protection of Timber against Termites (W. Victor Harris) 49
Note on a Method of Preserving Separated Milk as Cheese (M. A. Barrett) 51
A Metal-lined Pit Charcoal Kiln 53

INDEX TO ADVERTISERS

PAGE
African Mercantile Co., Ltd. XIX
Arthur A. White, Ltd. XIX
Barclays Bank (D.C. & O.) VI
Baumann & Co. VII
Bovill, Matheson & Co., Ltd. XVI
British East Africa Corporation (1939), Ltd. IV
Bruce, Ltd. X
Bullows & Roy, Ltd. XVIII
Caltex (Africa), Ltd. .. .. .. COVER PAGE 3
Cooper & Nephews, S. Af. (Pty.), Ltd. .. XV
Craelius East African Drilling Co., Ltd. .. VI
Dunlop Tyres .. .. COVER PAGE 4
East African Breweries IX
East African Railways & Harbours II
E.A. Tanning Extract Co., Ltd. XIV
Farrell Lines III
Gailey & Roberts, Ltd. ("Zondagam") .. XI
Imperial Chemical (Pharmaceuticals), Ltd. .. V
Kassam Kanji & Son, Ltd. XVIII
Kenya Farmers' Association (Co-op.), Ltd. XIII
Leslie & Anderson (Nairobi), Ltd. I
Macgregor-Oates Motors, Ltd. VIII
National Bank of India, Ltd. IV
Ndurumo, Ltd. XVII
N. Shah & Co., Ltd. III
Shelltox XX
Smith, Mackenzie & Co., Ltd. .. COVER PAGE 2
Standard Bank of South Africa, Ltd. .. VII
Uganda Company, Ltd. XII

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Bulletin 39.—*Five Hundred Varieties of Herbage and Fodder Crops. Price Sh.* 15, *March,* 1948.

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The information, which is collated in this way for the first time, will reveal not only the need for a completion of the data by the inclusion of entries from other countries, but also the desirability of some attempt being made by research workers to achieve uniformity in regard to standards, nomenclature, synonyms, etc.

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Technical Communication No. 17.—*Chemical Composition of Plants as an Index to their Nutritional Status, by D. W. Goodall and F. G. Gregory. A Review of* 165 *pages with* 900 *references to literature. July,* 1947. *Price Sh.* 9.

Optimum nutrition is of paramount importance to plant yield. Yet the determination of the nutritional requirements of any plant is one of the hardest problems of agriculture and horticulture.

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THE EAST AFRICAN AGRICULTURAL JOURNAL

E.A.A.F.R.O.

In a recent issue (Vol. XIII, No. 2, October, 1947) there appeared a report of the Technical Session of the Agricultural Research Conference held at Nairobi in July, 1947. In the same issue an editorial dealt with the organization session of the conference at which the establishment, scope and duties of the East African Agriculture and Forestry Research Organization (E.A.A.F.R.O.), was discussed. A full account of the organization session is being printed as Paper No. 2 of a new series of pamphlets, issued under the aegis of the High Commission.

The capital and recurrent funds have now been agreed by the home and territorial governments, and both E.A.A.F.R.O. and its opposite number, the East African Veterinary Research Organization (E.A.V.R.O.) came into official existence in February, 1948. It is appropriate, therefore, to deal in this article with the general policy of E.A.A.F.R.O. and the methods by which that policy will be put into effect.

The first and most important problem, not only for E.A.A.F.R.O., but for other research organizations, is to secure a close but flexible co-operation with the relevant technical departments in the territories. Flexibility is the essence of the matter; attempts to draw up detailed organizational and administrative machinery to secure co-operation invariably defeat their own laudable aims. It is simpler and better to work on a broad general directive, and in the present case there is no difficulty in framing a very suitable one, as the following considerations show.

In subjects like agriculture, which are connected at the one end, with research in numerous pure sciences—physics, plant and animal physiology, etc.—and at the other with problems of propaganda, demonstration, and farming practices, it is possible broadly to distinguish a three-fold division or grouping into (*a*) basic or fundamental research, (*b*) technological investigations, and (*c*) introductions into farm practice. As one example, we can take the distribution and movement of moisture in the soil. In group (*a*) the physical laws are elucidated by research into such matters as water film curvatures, vapour pressures, thermodynamical relationships—all, obviously, matters for a research physicist, who will, in addition to his own researches, draw on the work of other physicists in the Universities and elsewhere. The knowledge so gained then needs to be tested under the ranges of climates, soil types and general environments found in East Africa. This constitutes group (*b*) and its study necessitates both scientific and agricultural perspectives. This work enables practical conclusions about soil moisture control to be formulated for the various types of farming systems, etc; it is the information needed by those responsible for implementing group (*c*).

From this example the form of the broad directive can be generalized: E.A.A.F.R.O. is responsible for groups (*a*) and (*b*); territorial departments of agriculture are responsible for groups (*b*) and (*c*). Therefore in group (*b*) which is the essential link between research and practice, there is the need, and the opportunity, for close collaboration amounting to joint work. The degree of collaboration will vary with the problem; it may be primarily a departmental investigation with only incidental help from E.A.A.F.R.O., or the reverse, or any intermediate combination, for it depends entirely on the nature of the problem and the object in view.

The work on fertilizers now in active progress is an excellent example of how this broad directive works in practice and of its flexibility. There are two fertilizer schemes. One was started as a matter of urgency before E.A.A.F.R.O. was established, with the provision that it will be absorbed into the organization in 1951. Its main immediate task falls into group (*b*) for it consists of a large number of statistically controlled field experiments on various soils and crops. The object is to obtain reliable answers to practical questions such as the following: on what soils and crops is phosphatic manuring advantageous; the relative effects of superphosphate, soda-phosphate prepared from the Uganda rock-phosphate, and ground rock-phosphate; the effects of nitrogeneous manures, both organic and artificial; the residual value of various manurial combinations.

It was soon apparent that the utmost efforts of this team could not secure a proper coverage of East Africa, if both native and European areas were to be adequately included. Therefore, the Kenya Government offered to institute a parallel scheme for the highlands, and to meet the whole of the recurrent costs. This project is, of course, under the administrative and financial control of Kenya. Both schemes are now in operation, one functioning on European areas in Kenya and the other mainly on African areas in Tanganyika and Uganda and Zanzibar. The two officers in charge work under the general scientific direction of E.A.A.F.R.O., and they are in effect operating one scheme, even to sharing a common headquarters, at Eldoret. They have the closest relations with the departmental agricultural officers in the districts where the experiments are being done; indeed, without their active co-operation and their local knowledge, neither scheme could have been properly carried out. The whole effort is a most encouraging example of smooth team work by agricultural departments and E.A.A.F.R.O. in group (*b*) (technological investigations).

Meanwhile a small team of E.A.A.F.R.O. research workers has begun the long-range investigations of the fertility status of East African soils. In comparison with our knowledge of the scientific factors underlying soil fertility in temperate climate soils, we know very little about tropical and sub-tropical soils. This investigation, therefore, falls into group (*a*), but it is closely linked with the technological work just described, because soil and crop samples from the actual experimental plots will be used in the research work.

The broad classification into three groups discussed above in relation to the work of the agricultural departments and E.A.A.F.R.O., is also applicable in other directions. It has provided a simple and yet sound basis for co-ordinating the programme of E.A.A.F.R.O. with those of the Empire Cotton Growing Corporation and the Overseas Food Corporation operating the ground-nuts scheme. Further, and by no means the least significant, it provides for the common interests of E.A.V.R.O. and E.A.A.F.R.O. in animal husbandry. This subject extends from purely veterinary problems at one extreme to purely agricultural ones at the other, but in between, and in the aggregate more important than the extremes, is a wide range of problems that are both veterinary and agricultural in varying degrees. These research and technological problems will be tackled by both organizations working as one. Once a particular problem is defined, appropriate workers from both organizations will be formed into a team to study it. The choice of the workers and of the team-leader will depend only on the nature of the problem. Practical effect has already been given to this agreement by the decision to have a common department of animal husbandry for both organizations, although for reasons of space and administrative convenience the department will be at the Maguga headquarters of E.A.A.F.R.O., about 12 miles from Nairobi.

B.A.K.

CORRIGENDA

Vol. XIII, No. 4, page 237.—The scale shown refers to Fig. 2 only (3.3 cm.: 4 feet). Fig. 1 is on half this scale (3.3 cm.: 8 feet).

Vol. XIII, No. 4, page 196: "Figure II—Column A represents the coupe felled in the tenth year; Figure III—Column D represents the coupe felled in the thirteenth year".

THE CULTIVATION OF INTRODUCED PASTURE PLANTS

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The advancement of economic botany accelerated the search for useful plants. Extensive collections were made from all over the world and plant introductions to different centres were numerous. Quite early, however, it became evident that most species could only be successfully grown under conditions similar to those prevailing in their respective natural environments. Generally speaking, plants from tropical regions cannot be grown profitably in temperate climates, and plants which grow under high rainfall conditions and on certain soil types do not generally thrive in arid regions or under different soil conditions. There are numerous examples of crops such as rubber, quinine, cocoa and cloves which have to be grown in the tropics as they cannot be produced in colder climates.

More recently the propagation of introduced pasture and fodder plants has received much attention and a number of very useful species has been selected for extension work under field conditions on a comparatively large scale. This essential preliminary work has been of great value, but in future the introduction of pasture and fodder species should be carried out with discretion. I do not decry importations, in fact I strongly encourage the introduction of promising pasture and fodder plants. In many instances our knowledge regarding the range of conditions under which certain species would thrive is still very meagre though it is also abundantly clear that the degree of success with which these introduced species can be propagated depends to a very large extent upon the management they receive. Such pasture and fodder plants require just as much attention and skilful handling as other crops and they should not be established on poor land which has been discarded because it is no longer of any use for other purposes. Given the necessary attention there is considerable scope for using some of the more promising species in areas where ecological conditions resemble those of their natural habitat.

During visits to various centres in the Union of South Africa, Southern Rhodesia, Kenya and Uganda I have noted the approximate number of grasses and other fodder plants introduced to different experimental stations and private estates, and those which have proved to be of most use. The tables in this article may be of interest in this connexion. The numbers quoted are only approximate and in some cases the introductions may have been far more. The species described as useful ones for fodder and pasture are not necessarily those grown on a large scale, but may be included for various other reasons such as the following:—

(*a*) They can be successfully established on a field scale.

(*b*) They do not only grow vigorously for one or two seasons, but continue to thrive over a period of years.

(*c*) There is a demand from private farmers who have proved the value to their own satisfaction.

(*d*) They do not yield good results on one or two isolated stations only, but within certain soil and climatic limits they do well over extensive regions.

(*e*) They can be developed for specific purposes such as soiling, ensilage, hay and grazing.

In previous articles (8–9) I have stressed the need for the proper utilization of indigenous pasture and fodder plants and for their sound management. Careful handling and much attention is required in connexion with the propagation of either local or introduced pasture and fodder species and the scale on which such work is contemplated should be carefully considered.

It is noticeable that the thirty-odd species mentioned as the most useful pasture and fodder plants have for many years been recognized as promising fodder plants. A number of them have become prominent during the past 10 to 12 years and have gained in popularity, for example, *Acroceras macrum*, some varieties of *Setaria sphacelata* and *Hemarthria* sp. It would appear that during the past 12 years or more there have hardly been any worthwhile discoveries of new fodder and pasture species. It is therefore necessary that we should re-arrange the material we have got and think in terms of improved farming rather than of a "wonder species" that will be the automatic salvation of all our problems.

The following species may be quoted as valuable plants for fodder and the establishing of pasture, although under natural conditions a large number of others play an important role in mixed grazing.

(i) Those regarded as the more important species:

Acroceras macrum ("Nylgras").
Chloris gayana (Rhodes grass).
Cynodon plectostachyum (Star grass).
Panicum makarikariensis.
Pennisetum clandestinum (Kikuyu grass).
P. purpureum (Elephant grass, Napier fodder).
Setaria sphacelata (Kazungula millet grass and other varieties).
S. splendida (millet grass).

(ii) Other species which are also promising:

Bothriochloa insculpta (turf grass).
Brachiaria decumbens.
B. humidicola.
Cenchrus ciliaris (African fox-tail grass).
Cynodon dactylon (Rietondale lawn grass).
Digitaria decumbens (finger grass).
D. eriantha (Pongola finger grass).
D. eriantha (Rhodes Matopos Estate, finger grass).
D. eriantha (Waterfall, finger grass).
D. Swazilandensis (Swaziland finger grass).
D. Sp. (Dunn's finger grass).
Echinochloa pyramidalis (Antelope grass).
Hemarthria sp. (Swamp Couch grass or "Rooikweek").
Panicum maximum (guinea grass).
P. repens.
Paspalum dilatatum.
P. Urvillei.

Clover, cowpeas, lucerne, soya beans, sunn-hemp and velvet beans are the most widely used legumes.

NOTES ON THE DISTRIBUTION AND USES OF THE SPECIES MENTIONED ABOVE

Acroceras macrum.—This grass has a very wide distribution and has been collected from Zululand, the Northern Transvaal, Northern Rhodesia, Tanganyika and Angola. During the early nineteen-thirties roots from the Northern Transvaal were collected and established at the Rietondale Grass Introduction Station near Pretoria. A few years later planting material was distributed to other centres, and it was found to do well at Athole in the Eastern Transvaal and along the Natal north coast at altitudes ranging from 1,000 to 4,000 feet with a rainfall of 35 to 60 inches. It rapidly gained popularity in the mist belt and does best in high rainfall areas where the dry season is not very long.

Acroceras macrum occurs in the Iringa district of Tanganyika and has been collected from the Lihogosa swamp near Njombe at an altitude of over 5,000 feet and a rainfall of about 40 to 45 inches per annum. It might be worth while cultivating in the high rainfall mountainous regions or in the coastal areas, but it would not thrive in arid central Tanganyika unless grown under irrigation. It is principally a hay or pasture grass growing about three feet high and is capable of yielding heavy hay crops of excellent feeding value. Unfortunately, however, it does not produce viable seed and has to be propagated from stolon cuttings. Furthermore, it is sometimes difficult to eradicate on cultivated fields and is therefore not very suitable for ley farming.

Chloris gayana.—Rhodes grass has a very wide distribution and is indigenous to East Africa, Rhodesia and South Africa. It is a valuable pasture and hay grass and is one of the few species from which seed has been produced in bulk for commercial purposes. This grass was first cultivated by the late Cecil Rhodes, about 1895. In 1903 it was introduced into the United States of America and Australia, and it succeeded so well in New South Wales that seed has been exported to America and even to South Africa, the country of its origin.

It does best in fairly warm regions on fertile soils and with a rainfall of 30 to 50 inches per annum. In parts of Kenya and Uganda it rapidly colonizes fallow lands provided that these are not cultivated continuously for more than about three years. It forms an excellent ley pasture which is easily ploughed out when the land is again cultivated. In part of South Africa it is also successfully used for temporary leys, for example, at the Pretoria University Experimental Farm and on farms in the Eastern Cape Province. Seed supplies have been very limited during recent years due to labour costs and the unavailability of the necessary machinery, but production is once more on the increase.

Rhodes grass occurs in many parts of Tanganyika and is prominent over large areas of the Southern Highlands and Northern

Provinces in places where the rainfall exceeds 25 to 30 inches per annum. In the more arid regions it is generally confined to river banks and to the margins of flood areas and valley bottoms.

Cynodon plectostachyum.—This species is a most valuable pasture and hay grass which is native to East Africa and occurs abundantly in the semi-arid areas. It is a runner grass that thrives best under conditions of controlled grazing and mowing; it is unable to compete with tall erect-growing grasses in burnt grassland or in thicket formations. A height of two to four feet may be reached, and very long runners, sometimes over twenty feet in length, which readily root at the 24 nodes, are formed. While it has not yet been possible to produce sufficient quantities of viable seed to propagate star grass under field conditions, it has been found practicable to plant relatively large areas from roots as these can be spaced six feet apart or more.

Cynodon plectostachyum was first introduced into South Africa in 1919, but on the whole it did not seem to stand up well to low temperatures and frost on the Highveld. Furthermore, its distribution to farmers was prohibited on account of the suspected poisonous properties of this species under certain conditions, such as drought and frost. At the same time, herbage samples from plots of this grass which had been grown in New Zealand were found to contain very high percentages of hydrocyanic acid which caused yet further alarm. During more recent years star grass has been successfully established under field conditions in the relatively frost-free areas of the Natal coast and no ill-effects occurred amongst dairy cattle grazing on these pastures throughout the year.

Unlike Kikuyu grass (*Pennisetum clandestinum*) star grass does not develop deep-rooted stolons and is not difficult to eradicate from cultivated land although it has been troublesome where it became a weed in high rainfall areas and where weeding had to be done during wet weather.

Panicum makarikariensis. — This grass originates from Bechuanaland where it grows in the vicinity of the makarikari pans. Roots for propagating at Pretoria were collected probably more than 20 years ago and it has been established on many experimental stations in the Union. It provides very nutritious pasture and is extremely palatable, but it is slow to establish as most strains have to be planted from roots and it requires a considerable amount of attention and upkeep in order to prevent it from being ousted by other species. Comparatively large fields, with a total area of sixty acres, were planted in Natal and did well for the first few years after establishment, but they then had to be replaced because the cover rapidly deteriorated. In Southern Rhodesia it is highly thought of and it is doing well at Matopos, Gatooma, Salisbury and Gwebi. Selections are now being made of varieties producing viable seed.

Panicum makarikariensis would grow well in some of the high rainfall areas of Tanganyika, for example, in parts of the Morogoro, Moshi and Arusha districts, but until such time as viable seed can be produced in bulk I doubt whether it would be advisable to cultivate it in preference to some of the indigenous species of Panicum.

Pennisetum clandestinum.—Kikuyu grass is a native of the high-altitude areas of East Africa, and is dominant over extensive areas of the Kenya Highlands from where it was exported to South Africa more than 30 years ago. It was tried extensively and was reported on very favourably as a pasture and soil binding grass by H. A. Melle in 1922 [11], and it was also doing well in many parts of the Union; particularly in Natal. To quote from a more recent article from Fisher [5]: "I do not know what returns have been secured by good management of good dairy cows and good pastures in the coastal belt but there is no doubt in my own mind that 600 to 800 or 1,000 gallons per acre could be secured."

Kikuyu grass thrives best on fertile soils under relatively high rainfall, and in areas where the dry season is not very long. The development of strong rhizomes, and the fact that it has to be planted from roots, makes its use as a short-term pasture or ley practically impossible in many areas. It forms a dense sward which can stand very heavy grazing.

During the past 20 years Kikuyu has been developed as a pasture grass in Kenya. It is highly thought of and on some of the farms at Njoro it is grown successfully in three-year leys alternating with crops of wheat; its eradication in this instance does not present much difficulty. It is most successfully grown for pasture between 5,000 and 8,000 feet altitude.

In Tanganyika it also occurs under natural conditions at altitudes of over 5,000 feet if the rainfall exceeds 35 inches per annum, for example, at Tukuyu and along the Mporoto mountains, on the Usambara mountains in the Tanga Province and on parts of the Mbulu

Highands, notably at Ng'oro Ng'oro, where it grows mixed with indigenous clovers forming excellent mixed pasture. It can be successfully propagated under conditions similar to those prevailing in the areas mentioned, but under different conditions in other parts of the territory there is only very limited scope for using it on an extensive scale.

Pennisetum purpureum.—Uganda is generally looked upon as the home of the Elephant grass, though it is widely distributed throughout East Africa and Rhodesia. In Buganda it is readily sef-propagated from seed and commonly occurs on hillsides, but in the drier regions it is confined to river beds and swamps. It grows more than 20 feet high and can produce a large bulk of valuable green fodder if cut periodically before the stems become too hard and fibrous. A considerable amount of work has been done on selecting glabrous and succulent types which are easily handled and yield better crops than do some of the thin-stemmed ones which tend to become fibrous quickly. Elephant grass is at present widely grown for soiling, ensilage and grazing, and in some parts of the Union there is a great demand for planting material, principally from dairy farmers. It can be grown under a very wide range of conditions though it requires a great deal of moisture and in semi-arid areas it can only be grown under irrigation or along stream banks and irrigation furrows.

Elephant grass has a very vigorous root system and is excellent for building crumb structure especially when growing on loam or clay soils in high rainfall areas such as Buganda [8]. Generally it does not do very well in large blocks possibly due to nitrogen depletion and root competition. Growth inside such fields becomes stunted and yellow while around the perimeter it remains vigorous and green. It seems to do best when planted in narrow belts or along field margins, but it should be planted a reasonable distance (about six to eight feet or more) from crops because it has an extensive and spreading root system.

This grass can be propagated almost anywhere in Tanganyika from sea level to altitudes of 6,000 feet and more, provided that there is sufficient moisture and that a high level of soil fertility is maintained. In parts of the Mahenge district in the Eastern Province it is used for stall feeding dairy cattle in tsetse-fly areas, and some herds receive practically nothing else but young elephant grass, cut when about three feet high, and a small quantity of cotton seed. Most of the grass is cut along the edges of stream banks and three to four cuttings are obtained per year. Some of the cows fed in this way produce up to two gallons of milk per day. Elephant grass can be used much more extensively in many parts of the territory as a fodder plant.

Setaria sphacelata.—A number of varieties of this and other species of rather similar growth form, occur throughout East Africa, Rhodesia and South Africa. They are generally confined to level fertile plains or valley bottoms where the soil-moisture remains at a reasonably high level. They provide most excellent swamp grazing, often shooting before, or staying green after, the other grasses have died off. Some of these have been cultivated in South Africa for many years and in 1937 a number of specially selected succulent varieties were collected from Bechuanaland, Rhodesia and East Africa. These have since received a great deal of attention and have given most excellent results in some parts of the Union [2]. Most of them produce a fairly high percentage of viable seed. In some parts of the Union they are used extensively for green fodder ensilage and hay. Homogeneous high seed yielding strains are now being propagated for seed production. Some of these can be grown successfully in Tanganyika in high-rainfall areas or under irrigation.

Setaria splendida.—This grass, of which planting material was originally collected in Nyasaland, was introduced to South Africa more than ten years ago. It took a long time to get beyond the nursery stage, but during recent years it has been cultivated on a fairly large scale in the high-rainfall coastal belt of Natal and in the Northern Transvaal. Good use could be made of this grass in the high-rainfall coastal and mountain areas in Tanganyika or under irrigation with intensive treatment.

Bothriochloa insculpta.—This grass occurs throughout East Africa, Rhodesia and South Africa. It is a valuable pasture and hay grass in indigenous pastures in semi-arid regions. It occurs over extensive areas in the Lake and Central Provinces and forms excellent pasture with proper grazing management. It has been planted under nursery conditions, but has not been propagated on a large scale due to the difficulty of collecting seed in sufficient quantities.

Brachiaria decumbens.—This species occurs in the Buganda Province of Uganda and plots of it which have been established at Kawanda are relished by stock. Some of it established on a small plot at Mpwapwa has grown well under nursery conditions, but this grass has not yet been established on a field scale on account of the difficulty of collecting seed.

Brachiaria humidicola.—In Rhodesia and South Africa plots of this grass have been established in connexion with soil improvement and grazing trials. It is, however, a shy seeder and has not been grown successfully on a large scale. It forms a valuable grazing constituent on sandy soils in part of the Western Province of Tanganyika where the rainfall is about 35 inches per annum.

Cenchrus ciliaris.—This plant is a valuable pasture grass, widely distributed in South Africa, Rhodesia, and East Africa. It is resistant to drought and occurs abundantly in the semi-arid areas. Irregular seeding and the difficulty of collecting seed in sufficient quantities are the main reasons why it is not cultivated on a much larger scale. It is a most useful constituent of natural grazing in Tanganyika, particularly in the Central, Northern and Lake Provinces.

Digitaria decumbens.—This seems to be a promising pasture grass in cultivated plots at Pretoria, but here again the difficulty of producing viable seed is a great disadvantage in establishing it.

Digitaria eriantha.—A very valuable pasture grass widely distributed throughout South Africa, Rhodesia and East Africa. Numerous attempts have been made to cultivate some of the many varieties of this species, and areas of considerable size have been planted from roots as it is a rather shy seeder which produces only a very small percentage of viable seeds. Some varieties of this grass are conspicuously abundant on the sandy soils of the Western Lake and coastal Provinces of Tanganyika.

Echinochloa pyramidalis.—A typical water-edge or swamp grass and a valuable pasture and fodder species. Planting from roots is the only practical way of establishing it and there is little or no scope for establishing artificial pastures of it on a large scale. Many different varieties occur throughout East Africa, generally in swampy areas along the permanent rivers. In Tanganyika, along the Ruaha and Kilombero river valleys, it occurs over large areas and forms a most valuable natural pasture when the water-level recedes from some of the flood-plains. Some varieties also occur in Rhodesia and South Africa.

Hemarthria spp.—Several varieties of *H. fasciculata* and other species occur along swamp edges in East Africa, Rhodesia and South Africa. A leafy variety collected in the Mbeya district of the Southern Highlands Province, Tanganyika, was successfully cultivated in vlei (swamp) pastures in the Northern Transvaal and in Natal. Unfortunately, however, only very few seeds are produced and it has to be established from roots or cuttings.

Panicum maximum.—This is an excellent pasture and fodder grass in the semi-arid regions of Southern Africa. A fairly large percentage of viable seed is formed and it is a promising species for producing seed commercially; it has, however, the great disadvantage that it grows unevenly, and mature plants vary from three to twelve feet in height. Furthermore, the ripening of seed is also very uneven and those on the lower part of the inflorescence often fall long before those on top are ripe. It is necessary to select suitable short and even-ripening varieties for seed production.

Panicum maximum seeds well under natural conditions and grows either in pure stands or mixed with other species. It is primarily a bunch grass, but it thrives well in mixed pastures where other species cover some of the ground.

Panicum repens.—This grass is widely distributed throughout Southern Africa. It thrives on moist sandy soils and is generally restricted to swamp margins. It is similar to Kikuyu grass in habit and develops strong rhizomes and is unsuitable for use in establishing short-term leys as it is difficult to eradicate. It is planted from roots or rhizome cuttings. Although it has been used with good results for vlei (swamp) pastures and around dam walls there is little scope for establishing large pastures of this species.

Paspalum dilatatum.—*P. dilatatum* is a pasture grass introduced from South America, and it has been cultivated in South Africa, Rhodesia and parts of East Africa for many years. It thrives best on moist soil and does well in vlei pastures either planted by itself or mixed with other species. It also has the advantage of providing early and late grazing often before some of the other grasses start shooting or after they have already died. It seeds well and seed is being propagated commercially, though often it is slow in germinating during the first season. In some parts of the Union this difficulty has been overcome by sowing

Rhodes grass mixed with *Paspalum dilatatum*. The former is quicker to germinate and cover the soil, but it does not affect the *Paspalum* adversely and a useful mixed sward is obtained.

Paspalum urvillei.—This species, which was also introduced from South America, has been successfully cultivated in South Africa and Southern Rhodesia. It is a coarse, tall, tussocky plant which grows on moist fertile soil and is suitable for making ensilage. Like *P. dilatatum* it remains green much longer than most of the indigenous species and provides a certain amount of grazing after the other grasses have turned brown. It often establishes itself on favourable sites along road embankments and stream banks in areas where seeds are distributed from cultivated fields. Seed is being produced commercially.

P. urvillei can be grown in some of the high-rainfall areas of Tanganyika, for example, in the Southern Highlands Province, the coastal Provinces and parts of the Northern and Western Provinces.

TABLE GIVING THE APPROXIMATE NUMBER OF SPECIES ESTABLISHED AT DIFFERENT CENTRES

Centre where Planted	Approx. No. Spp.	Most Valuable Species	Other Promising Species	Legumes
Athole Pasture Experiment Station (E. Transvaal)	126 Grasses 44 Legumes	*Acroceras macrum* *Setaria sphacelata*	*Paspalum dilatatum* *P. urvillei*	
Cedara Agricultural College (Pietermaritzburg, Natal)	200	*Pennisetum clandestinum* *P. purpureum* *Setaria sphacelata*	*Paspalum dilatatum*	Clover
Drylands (Pretoria) ..	50 (including about 20 varieties of Spineless Cactus)		*Digitaria eriantha* (Waterfall)	
Escourt (Natal)	350	*Chloris gayana*	*Paspalum dilatatum* *Pennisetum clandestinum*	
Fairfield (Cape)	60	*Acroceras macrum*	*Digitaria eriantha* (*Pongola*) *Echinochloa pyramidalis*	
Fernwood (Groote Schrur, Cape)	100	*Setaria sphacelata*	*Digitaria decumbens* *D. Swazilandensis* *D. sp.* (*Dunn's Finger grass*) *Echinochloa pyramidalis*	
Frankenwald (J'burg) ..	600 (indigenous and introduced)	*Chloris gayana* *Pennisetum purpureum* *Setaria sphacelata*	*Paspalum dilatatum* *P. urvillei*	
Jukskei River (J'burg) ..	200	*Setaria sphacelata*		
Kiesenbos (Malmesbury, Cape)	30	*Acroceras macrum* *Setaria sphacelata*	*Echinochloa pyramidalis*	
Magaliesberg (Transvaal)	50	*Pennisetum purpureum*		
Prinshof (Pretoria) ..	640 (species and varieties)	*Digitaria eriantha* *Setaria sphacelata*	*Digitaria Swazilandensis* *Pennisetum clandestinum*	
Doornkop, Kearsney and Umsimkulu (Natal Coast)	200	*Acroceras macrum* *Cynodon plectostachyum* *Pennisetum purpureum* *Setaria sphacelata* *S. splendida*	*Panicum maximum* *Pennisetum clandestinum*	Velvet beans Sunn hemp
Rietondale Grass Introduction Station (Pretoria)	2,000 (species and varieties)	*Acroceras macrum* *Cynodon dactylon* (*Rietondale*) *Digitaria Swazilandensis* *Panicum makarikariensis* *Pennisetum clandestinum* *P. purpureum* *Setaria sphacelata*		Cow peas
Rietvlei (Pretoria) ..	50	*Pennisetum purpureum* *Setaria sphacelata*		
Rust Der Winter (Transvaal)	600 including 24 varieties of lucerne and about 50 other legumes	*Acroceras macrum* *Pennisetum purpureum* *Setaria sphacelata* (Local *Panicum maximum* and *Urochloa pululans* do extremely well under natural conditions in this area)		Cow peas Lucerne Velvet bean

NATAL NORTH COAST

1. A variety of *Pennisetum pupureum* introduced from Uganda. A field ready to be cut for ensilage.

2. *Acroceros macruum* ready to be cut for hay.

TABLE GIVING THE APPROXIMATE NUMBER OF SPECIES ESTABLISHED AT DIFFERENT CENTRES

CENTRE WHERE PLANTED	APPROX NO. SPP.	MOST VALUABLE SPECIES	OTHER PROMISING SPECIES	LEGUMES
Towoomba (Transvaal) ..	65 grasses 50 other species	*Pennisetum purpureum*		
University (Pretoria) ..	30	*Acroceras macrum* *Chloris gayana* *Setaria sphacelata*		
Vergelegen (Cape) ..	60	*Pennisetum clandestinum* *P. purpureum*		
Westfalia Estate (Northern Transvaal)	60	*Pennisetum purpureum* *Setaria sphacelata* *Setaria splendida*	*Hemarthria sp.*	Clover (*Trifolium repens*) Lucerne
Southern Rhodesia (At Matapos, R.M.E.; Grasslands Marandellas, Gatooma, Gwebi and Salisbury station)	About 250	*Chloris gayana* *Cynodon plectostachyum* *Panicum makarikariensis* *Pennisetum purpureum* *Setaria sphacelata*	*Brachiaria humidicola* *Digitaria eriantha* (*R.M.E.*) *D. eriantha* (*Waterfall*) *D. Swazilandensis* *Paspalum dilatatum* *P. urvillei*	
Kenya (At Kabete, Maseno Kisii, Kericho, Bukura, Rumuruti and Ol-joro O'rok)	About 350	*Chloris gayana* *Cynodon plectostachyum* *Pennisetum clandestinum* *P. purpureum*	*Bothriochloa insculpta* *Cenchrus ciliaris* *Panicum maximum*	*Trifolium johnstonii*
Uganda (At Kawanda and Serere)	About 250	*Chloris gayana* *Pennisetum clandestinum* *P. purpureum* *Setaria sphacelata*	*Brachiaria decumbens* *Panicum maximum* *P. repens* *Paspalum dilatatum* *P. notatum*	

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ASCOCHYTA BLIGHT OF COTTON

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Early in February, 1947, an unusual disease was noticed in cotton plants at Lubaga in the Lake Province. All the plants on an area of thirty-five square yards were affected, and most were killed outright (fig. 1). From specimens sent to the laboratory the disease was diagnosed as Ascochyta blight, caused by the fungus *Ascochyta gossypii* Syd., and this diagnosis has since been confirmed by the Commonwealth Mycological Institute, Kew. Some weeks later the Province was visited by the Plant Pathologist, who, during a survey of the cotton grown in the Shinyanga and Mwanza areas, found no further definite outbreaks. In April, 1948, Mr. A. N. Prentice observed the disease in a small area at Ukiriguru, also in the Lake Province. Specimens sent to the laboratory were found to be typical.

Occurence

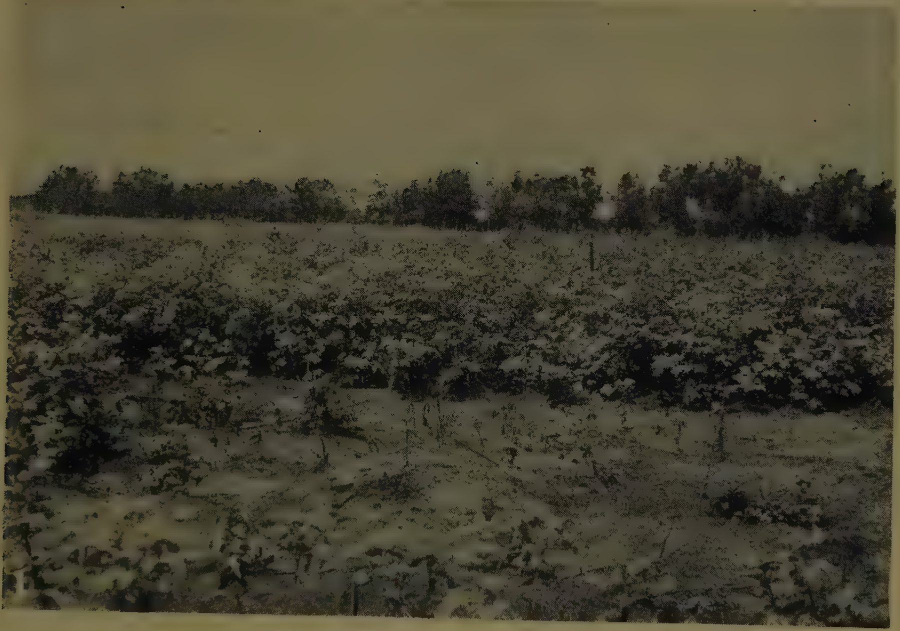
Ascochyta blight of cotton was first recorded from Kashmir in 1908. In 1915 and 1920 it caused serious loss in Arkansas, U.S.A. Since then the disease has appeared sporadically in epidemic form in most of the States of the American cotton belt. The fungus has been reported from the North Caucasus, the Argentine and possibly Queensland; Hansford lists a leaf spot of cotton caused by *Ascochyta gossypii* in Uganda, and Massee states that this fungus, among others, was isolated from the roots of cotton plants in the Sudan. In 1928 a species of Ascochyta was recorded as causing a leaf spot of cotton in Tanganyika territory. From drawings and measurements made then, and from a re-examination of the specimens, it is now clear that this was *A. gossypii*. In December, 1947, cotton lint from the crop grown that year at Lalago, on the Maswa–Shinyanga border, some forty miles from Lubaga, showed pycnidia and spores of *A. gossypii*. There is however, apparently no record previous to the 1947 one at Lubaga, of the "stem lesion" or more serious phase of *A. gossypii* in East Africa.

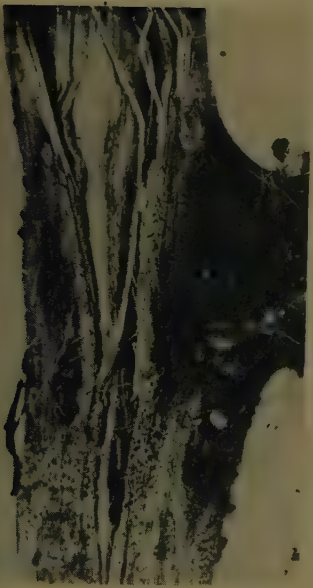
It can be deduced from the various accounts in the literature, and from the experience in this territory, that the fungus is potentially serious but that it is often present in a comparatively innocuous form, causing mild leaf and petiole spotting and discoloration of old lint. When conditions are particularly favourable for the development of the parasite, as in periods of cool wet weather, it becomes actively parasitic—stems and petioles are attacked, large elongated lesions being formed, and the plants may be killed. This is the "stem lesion" phase, or the typical Ascochyta blight. All accounts of this phase agree in that it appears only during, or immediately after, abnormally wet seasons, and that with the onset of drier weather, the spread of the disease is checked. Less badly affected plants may in fact recover and bear a fair crop. This was so at Lubaga where the few plants in the diseased area which had not succumbed subsequently produced some new healthy foliage from the base of the plants. The occurrence of the disease at Ukiriguru in April, 1948, during what was described as an abnormally dry season would appear to be exceptional.

Symptoms

Ascochyta blight can attack all above-ground parts of the cotton plant with the exception of the flowers. The less serious but more common "leaf spot" phase takes the form of rounded greyish-brown spots, sometimes with reddish borders. The centres of the spots become thin and papery, and may fall out. In a normal season these leaf spots cause little damage, but under very humid conditions the fungus spreads rapidly and constitutes a source of danger to the crop.

The stem lesion phase is much more striking. Dark brown areas occur on the stems, often at the base of the petioles. In a humid atmosphere these spots spread rapidly in a longitudinal direction, but lateral progress is slower. The lesions may attain a length of several inches. The centres become pale liver-coloured and covered with tiny black dots, the pycnidia or fruiting bodies of the fungus These can be seen clearly with a hand lens (fig. 2). Inside the pycnidia are the spores, colourless, one- or two-celled, and measuring





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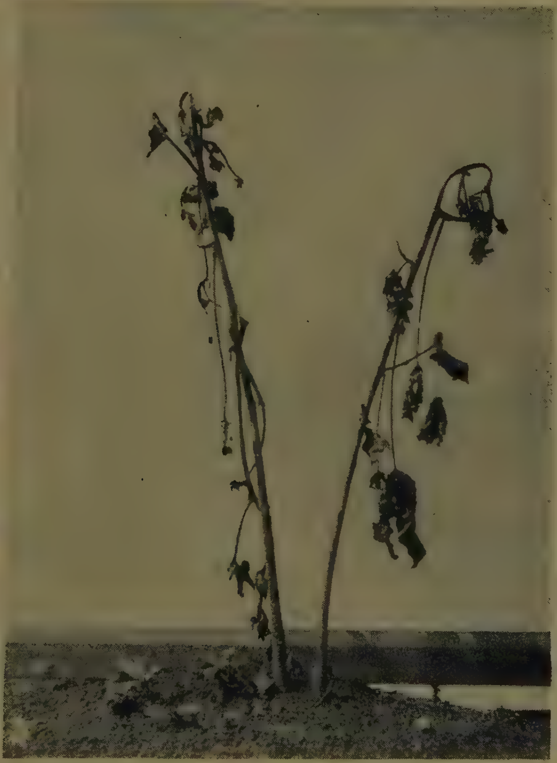

FIG. 1.—The area attacked by Ascochyta blight at Lubaga. Healthy plants in the background. *Photo. A.T.C.*

FIG. 2.—Enlargement of a stem lesion of Ascochyta blight. Note cracking; pycnidia seen as small black dots. *Photo. G.B.W.*

FIG. 3.—Two cotton plants wilted by Ascochyta blight. *Photo A.T.C.*

$6-12 \times 2\frac{1}{2}-4'$ microns. The bark becomes cracked and the softer tissues rot away leaving the internal stem fibres exposed. When the developing lesion encircles a petiole base, the affected leaf shrivels, droops and finally falls. When the main stem is girdled all parts above wilt and die, the tip of the shoot bending over in an inverted U (fig. 3).

Spots on the outside of cotton bolls are said to be similar to those on the stems, but such infections have not yet been seen in this country. In old lint the fungus threads ramify among the fibres producing aboundant pycnidia and blackening the cotton. Considerable loss of seedlings has been reported in Georgia.

The disease in its early stages can be confused with Black Arm (*Xanthomonas malvacearum*). The initial stem discoloration and the cracking are common to both diseases, but the development of the paler coloured central areas of the lesions bearing numerous black pycnidia, serves to distinguish the Ascochyta blight.

The following details concerning the conditions under which the disease appeared at Lubaga are quoted from a letter from Mr. A. N. Prentice, Senior Scientific Officer, Empire Cotton Growing Corporation, who was then in charge of the experiment station: "The crop, apart from the diseased patch, is healthy and well grown. Planted 19-12-46; rains good since planting; on tied ridges, four feet apart, one foot spacing on the ridge, thinned to two plants per hole. Soil, a black loam, underlain at about two feet, as usual here, by nodular limestone. Strains of (affected) cotton: two, 0/53 a Cambodia XU4 type, and MU8 an Indian type, but both are essentially American Upland cottons. Source of seed: Lubago, grown for several years. The seed had been acid delinted before planting . . . The disease was first noticed on four adjacent plants on 6–2–47; by 3–3–47 the disease was covering a patch of about 7×5 yards. All plants within this patch are diseased, most badly and none completely free; the perimeter plants are obviously attacked later and more lightly . . . Most of the affected plants seemed to be killed outright." The weather was described as damp and "muggy".

CONTROL

Information on control measures appears to be somewhat scanty. Some guidance however can be given from what is known: first, since the parasite can spread rapidly through a crop and is potentially destructive, it is essential to maintain a close watch for it throughout the growing season, especially during and after wet weather. Diseased plants should be destroyed at once. Secondly, it is known that the fungus can survive from one season to the next as a saprophyte on dead cotton trash; therefore the practice of uprooting and burning at the end of the season becomes even more important, particularly in fields where the disease has been found; and this operation should be very thoroughly carried out. Thirdly, crop rotation has been suggested as a possible means of eliminating the disease, and should be practised. It is not known whether the disease is seed carried.

ACKNOWLEDGEMENTS

The original discovery of Ascochyta blight at Lubaga is credited to the observation of two African Recorders who made notes on the symptoms and brought the problem to the notice of Mr. A. N. Prentice, Senior Scientific Officer, E.C.G.C. The latter sent material to the laboratory along with full notes on the disease as it appeared in the field.

The photographs in Figs. 1 and 3 were taken at Lubaga by Mr. A. T. Culwick, M.B.E., that in Fig. 2 at the laboratory.

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TESTS OF INSECTICIDES ON CATTLE

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This work was originally undertaken to investigate the possibilities of control of tsetse flies by treating cattle. As it concerns the persistency of various formulations applied to cattle, it may, however, be relevant to the control of other pests.

Matthysse (1946) reported control of hornflies (*Lyperosia irritans* L.) with a D.D.T. dispersible powder. Norris (1947) records control of Buffalo fly *Siphonia exigua* (de Meijere) using D.D.T. solutions and emulsions. He confirms results found elsewhere that persistance of D.D.T. on hide is notably greater than on the living animal. He concludes that the effects of rainfall, insolation, dust and mud are less important than the effects of licking, rubbing, and the possible effects of skin secretions, loss of hair, absorption and desquamation of epithelium. The effects of licking were anticipated in the work described here, and the neck area was therefore chosen as the area for exposure of the flies. Both the above insects are reported to remain on the animal a considerable time whereas the tsetse fly resorts to an animal for feeding only.

Whiteside (1946) treated cattle with a solution of 9 per cent D.D.T. in groundnut oil and found it necessary to spray cattle twice weekly to produce a satisfactory kill of *G. pallidipes*. In earlier reports he gives results of exposure of flies to locally made solutions and emulsions which gave poorer kills. His methods of estimating the effect of treated cattle on the tsetse fly population should be read in the original.

Vanderplank (1946) used gum arabic and ox serum as adhesives in locally made emulsions, and gives a list of some tsetse fly species in order of susceptibility to D.D.T. *G. palpalis fuscipes* was used in the experiments described here, as it was available in the laboratory. It is said to be less susceptible than *G. pallidipes* and more susceptible than *G. brevipalpis*.

Some uses of coumarone resin as an adhesive and adjuvant are summarized by Campbell and West (1946) and it was found to be of some value by Barnes (1946). Busvine (1946) working on head lice found emulsions containing coumarone resin showed higher toxicity, after washing of the hair, than emulsions without the resin.

The present tests were intended to find the most persistent preparation from the materials available at the time, with a view to possible larger scale tests later and the establishment of a technique for testing new preparations as they became available, e.g. adhesive dispersible powders. Boiled linseed oil was tried as an adhesive solvent, but when it dried no crystallization of D.D.T. occurred. This may account for the low toxicity observed when a thick deposit of the dried oil was still visible on the animals.

TESTS ON CALVES PROTECTED FROM RAIN

Irregular rainfall during the period of experiment is a complicating factor and would mask the effects of absorbtion, shedding of hairs, etc., in reduction of the insecticide. Also it was desired to test insecticides consecutively using the same animals. For these reasons the calves were protected from rain.

To give an estimate of the toxicity of any preparation, the following must be known within certain limits: (*a*) the amount of preparation on a given area; (*b*) the condition and environment of test insects during the experiment; (*c*) the effect of differences of surface to which the insecticide is applied. Both (*a*) and (*c*) are sources of inaccuracy in the application to inanimate surfaces. With regard to (*c*) it is difficult to obtain two animals with closely similar hair formation, and it appears impracticable to test different insecticides on the same animals, owing to the probability of mutual contamination.

Certain inaccuracies are inherent in the differences in behaviour, physiology and morphology of individual calves and test insects. In view of this, and the equipment available, a simple technique of spraying a known quantity from a given distance at a standard area was adopted, after other techniques had proved unsuitable for this type of work. The method is crude but is considered adequate to indicate gross differences in effectiveness of the different preparations.

Methods and Materials.—Calves were 16 to 18 months' old, and their weights varied from 39 to 100 kgms. They were kept in individual fly-proof stalls protected from rain, and were allowed to graze tethered in rainless weather, but were not allowed to come in contact with each other or with other animals. The sides of the animals were marked by shaved lines at intervals of approximately 12 cms. along the back, the lines extending down approximately 12 cms., making five equal areas.

Calves were secured to the expanded metal fence of an enclosure, and each area on the calf was sprayed with a large hand atomizer (flit-gun), a guide string being used to keep the nozzle at a distance of 71 cms. from the fence and 77 cms. from the ground. The nozzle of the flit-gun was centred roughly in the centre of each area and eight strokes of the hand pump given to spray each area. Spraying was done in windless conditions. Before each calf was sprayed, approximately 100 cc. of the test solution was poured into the flit-gun and the volume remaining after spraying was measured. The deposits obtained were sufficient to wet the test area thoroughly with little loss of insecticide due to run-off. Deposits of solid were visible after drying. The test area was the area demarcated nearest the head, i.e. in the neck region. It will be seen from the figures given for water, that the flit-gun is capable of delivering a quite constant amount of fluid when an attempt is made to use pump-strokes of constant force.

When paint was used, it was mixed well and applied liberally with a two-inch brush, using the quantity shown.

Tsetse flies (*Glossina palpalis fuscipes* Newst) emerged in the Laboratory from pupæ collected from the shores of Lake Victoria. Arrangements for production of flies and conditions before and after exposure are described by Hadaway and Barlow (1947) and there seems little doubt that insects of reasonably uniform susceptibility are produced. Flies 5–8 days' old were used. Ten flies were used in each exposure, five males and five females, except exposure 21 when three males and seven females were used, and no significant difference in susceptibility of the two sexes was observed. The calf was tied up lying on its right side, and the cotton wool stopper was removed from the 3 in. by 1 in. tube, and the tube inverted on the test area, the tube being tapped so that the fly was standing on the hide. Little trouble was experienced with flies refusing to settle. They were timed to spend 20 seconds on the treated surface. Each fly of the ten was placed on a different area within the test area. After exposure they were kept as described above.

The precautions against mutual contamination of calves with insecticides were as follows: in addition to separation of calves, the control calf was sprayed with water, using the same apparatus as with other calves, as significant carry-over of insecticide would have been marked by a corresponding mortality of control flies. Operators washed their hands after handling each calf, and each set of tubes.

In all tests except the penultimate one, formulation was repeated in the subsequent test to indicate the degree of reproduction obtained. Flies showing no signs of movement are shown as dead. Percentage mortality is derived from the expression % M =

$$\frac{\text{No. survivors control} - \text{No. survivors exposed} \times 100}{\text{No. survivors control}}$$

This expression has been frequently used in work of this type, but has the obvious disadvantage that if all exposed flies die, it indicates 100% M. as long as one control fly survives. High mortality of control flies implies either poor condition of flies, incorrect treatment, or contamination of control calf with insecticide.

TABLE I

SERIES 1

Calf	Exposure No. 15, 3 days after Treatment				Exposure No. 17, 7 days after Treatment				Before spraying cc.	After spraying cc.	Amount consumed cc.
	Flies dead		% Mortality		Flies dead		% Mortality				
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.			
A.	0	0	0	0	—	0	—	0	100	36	64
B.	0	1	—	—	—	0	—	0	100	42	58
C.	4	6	40	55·5	—	1	—	10	100	43	57

A. Sprayed with I.C.I. 5 gms. D.P. 530 (6·5 per cent gammexane) in 160 cc. water. This gives a low gammexane contact in the dispersion, but this sample did not stay dispersed well even at this dilution.

B. Sprayed with water.

C. Sprayed with 5 gms. Burroughs Wellcome dispersible D.D.T. Powder in 160 cc. water. Analysis of powder shows 31·5 per cent hydrolysable chlorine and 24 per cent p'p' corresponding to 0·98 per cent total D.D.T. and 0·75 per cent p'p' in the dispersion.

For the remaining readings, four and eight days were chosen as suitable times to elapse between treatment and exposure, and 24 and 48 hours as suitable times to elapse before recording of deaths after exposure. Ten, twelve and fourteen days were also recorded when warranted.

TABLE II
SERIES 2

Calf	Exposure No. 21 Flies dead		4 days % Mortality		Exposure No. 24 Flies dead		8 days % Mortality		Before spraying cc.	After spraying cc.	Amount consumed cc.
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.			
A. ..	4	8	40	60	0	3	0	20	100	35	65
B. ..	0	0	—	—	0	1	—	—	100	44	56
C. ..	1	3	10	30	1	2	10	10	100	38	62

A. As C. in series 1.
B. Water.
C. As A. in series 1.

TABLE III
SERIES 3

Calf	Exposure No. 26 Dead after		4 days % Mortality		Exposure No. 27 Dead after		8 days % Mortality		Exposure No. 28 Flies dead		10 days % Mortality	
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.
A. ..	2	5	20	37·5	1	2	10	20	0	2	0	0
B. ..	10	10	100	100	3	4	30	40	4	6	40	42·7
C. ..	5	7	50	62·5	2	4	20	40	2	2	20	0
D. ..	0	2	—	—	0	0	0	0	0	3	—	—

	Before spraying cc.	After spraying cc.	Amount consumed
A. As in series 2	100	42	58
B. 25 cc. of Tech. Products Emulsion T.P. 543, with coumarone resin added to 8 w/v, plus 75 cc. water	100	47	53
C. 25 cc. T.P. 543 (without resin) in 75 cc. H. 20 T.P. 543 contains 15 per cent p'p' D.D.T. ..	100	43	57
D. Water	100	47	53

NOTE.—On day 10, 12·2 mm. of rain fell between 09·13 and 10·15. Calves were exposed to this intentionally to see the effect of rain. Per cent mortality was already below 50 on day 8, so there was not question of confusing the data on a promising preparation. The rain fell in the morning, and flies were exposed in the afternoon.

TABLE IV
SERIES 4

Calf	Day 4, Exposure 30				Day 8, Exposure 31				Day 10, Exposure 52				Before	After	Used
	Dead		% Mortality		Dead		% Mortality		Dead		% Mortality				
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.			
A. ..	10	10	100	100	5	5	44	44	10	10	100	100	94	55	39
B. ..	10	10	100	100	5	6	44	65	6	7	55	66	99	44	55
D. ..	1	1	10	0	1	1	0	0	—	—	—	—	100	61	39
E. ..	7	8	70	75	0	0	0	0	—	—	—	—	100	64	36
F. ..	0	2	—	—	1	1	—	—	1	5	—	—	100	44	36

A. As B. in series 3 but 50 cc. of the formulation in 50 cc. of water.
B. As B. in series 3.
D. 50 cc. I.C.I. emulsion M.G. 035 (5 per cent gammexane) with 8 per cent w/v coumarone resin added, in 50 cc. water.
E. 50 cc. ATSO 1 (15 per cent D.D.T.) +. 8 per cent w/v coumarone resin in 50 cc. water.
F. Water only.

NOTE.—On day 10 it was noticed that a visible deposit of coumarone resin could be seen on the shoulders of calves A and B. These areas received a slightly heavier deposit during spraying. As kills were already below 100 per cent on day 8, it was decided to test on these areas on day 10, with the results shown.

Kills were still given by A and B on the shoulder area on day 14. On day 24, after washing with soap and water in an attempt to decontaminate the animals, they gave the following kills on the neck area:—

	A	B	F
After 24 hours	4	3	0
After 48 hours	4	5	0

TABLE V

SERIES 5

Calf	Day 4, Exposure 34				Day 8, Exposure 35				Before	After	Used
	Dead		% Mortality		Dead		% Mortality				
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	cc.	cc.	cc.
D. ..	8	—	80	—	1	1	10	10	Painted approx. 75 cc. used.		
E. ..	1	—	10%	—	0	1	0	10	100	69	31
F. ..	0	—	—	—	0	1	—	—	Not recorded.		

E. Sprayed with 50 cc. locally made up emulsion containing 25 per cent D.D.T. diluted with 50 cc. water.

F. Water only.

D. Painted with paint described by I.C.I. as "Paint for tsetse fly control" containing 10 per cent D. 939, i.e. 1·35 per cent gammexane. Heavy deposit still visible on day 8.

TESTS ON CALVES EXPOSED TO WEATHER

It was decided to test two of the more promising preparations on calves confined in paddocks. A fourth calf was used to test a dusting powder that was available. Methods of application were more like those encountered in practice, and dosage was indicated more by the state of the calves, e.g. thorough wetting, than by measurement of weight or volume. Control was untreated.

METHODS AND MATERIALS

Calves were 12–16 months old and weighed 79.5–98.0 kgms. One calf was kept in each paddock. Each paddock was approximately four acres square. They contained one or more shade trees and grass of leaf height up to about 45 cms. On the morning of the exposure they were put in individual fly-proof stalls in case a tsetse fly was accidently released.

Calves were sprayed on 18-3-47 and weather conditions up to the end of the experiment are shown in Table VIII.

TABLE VIII

METEOROLOGICAL RECORDS—OLD ENTEBBE

Calves treated 18-3-47

Date	Hours Sunshine	Temperature of		Rainfall in mm.	Evaporation	Relative Humidity	
		Max.	Min.			8·30 a.m.	2·30 p.m.
19–3–47 ..	5·30	77·0	64·5	0·0	1·5	79·0	86
20–3–47 ..	9·05	79·0	67·0	2·5	3·6	85·5	86
21–3–47 ..	4·50	68·0	64·5	1·2	2·0	85·0	81·0
22–3–47 ..	3·45	76·0	68·0	0·0	2·3	85·5	—
23–3–47 ..	—	—	—	0·0	—	—	—
24–3–47 ..	7·50	77·0	62·0	2·0	1·2	85·0	80·5
25–3–47 ..	6·15	76·0	65·0	0·0	0·5	66·5	69·5
26–3–47 ..	1·10	78·0	68·0	2·9	1·2	80·5	86·0
27–3–47 ..	2·40	78·0	64·0	15·0	0·5	89·5	76·5
28–3–47 ..	3·30	76·0	65·0	6·0	1·3	90·0	68·5
29–3–47 ..	6·55	78·5	66·0	0·0	—	90·5	—
30–3–47 ..	—	—	—	0·0	—	—	—
31–3–47 ..	11·30	74·0	64·0	0·0	1·0	71·0	90·5
1–4–47 ..	9·00	80·5	68·0	0·5	2·5	86·0	86·0
2–4–47 ..	4·45	77·0	65·0	0·0	3·7	85·0	85·5
3–4–47 ..	3·50	75·0	63·0	0·0	2·6	85·0	—
4–4–47 ..	—	—	—	2·1	—	—	—
5–4–47 ..	—	—	—	2·5	—	—	—
6–4–47 ..	—	—	—	0·0	—	—	—
7–4–47 ..	—	—	—	3·3	—	—	—
8–4–47 ..	—	78·0	65·5	0·0	15·5	87·0	68·0

Treatment of flies before and after exposure was as before. Calves E and G were sprayed with a knapsack type compressed air sprayer (Four Oaks Kent with No. 2 nozzle). This was manipulated so that the calves were thoroughly wetted once. The whole calf was covered except the head. Calf F was dusted with a hand dust blower (Dobbin's "Superbilt") to give a visible white deposit over most of the animal. The dust used was D.D.T./Diatomite and contained 8.1 per cent p'p'.

The concentrate used in spraying calves E and G was made up from Technical Products Emulsion T.P. 543 plus 8 per cent w/v coumarone resin. 25 cc. of the mixture was diluted with 75 cc. of water for calf E, and 50 cc. to each for calf G. Calves required 550 cc.–850 cc. for coverage. Calf H was left untreated as a control.

IRRITANT EFFECTS

A calf was later sprayed around the head and nose with the more concentrated preparation using a hand atomizer and no ill effects were seen after two days. The spray appeared to cause some skin irritation to the calves for a short time after spraying.

TABLE VI

Calf	Exposure No. 37, 4 days after Treatment				Exposure No. 38, 8 days after Treatment			
	No. dead after		% Mortality		No. dead after		% Mortality	
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.
E.	6	7	60	70	6	8	60	80
F.	0	0	0	0	—	—	—	—
G.	5	10	50	100	9	9	90	90
H.	0	0	—	—	0	0	0	0

As kill was nil on Day 4, F. was omitted from further tests. No residue of dust was visible on the animal on that day.

TABLE VII

Calf	Exposure No. 39, 10 days after Treatment				Exposure No. 40, 14 days after Treatment				Exposure No. 41, 21 days after Treatment			
	No. dead		% Mortality		No. dead		% Mortality		No. dead		% Mortality	
	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.
E.	2	4	20	40	0	1	0	10	1	2	0	0
G.	8	8	80	80	3	8	30	80	0	1	0	0
G2. ..	9	9	90	90	7	9	70	90	7	8	66·6	71·5
H.	0	0	—	—	0	0	—	—	1	3	—	—

For calves E., G. and H. the same methods as before were used.

G2 represents flies exposed on an area (the dewlap) still black with deposit of the coumarone resin on day 10. The deposit on the neck area consisted of small conglomerations of coumarone resin and hairs stuck together with a covering of dust, apparently due to the animal rubbing against termite hills. On day 14, the deposit on the area G2 was less obvious, and on day 21 it was no longer black and visible only as a matted effect on the hair. The inclusion of the G2 series of tests was to test the hypothesis that the coumarone resin gives kills approaching 100 per cent as long as it is visible as a blackish deposit. A visual indication of the toxicity of the skin of the animal to flies might be valuable under practical conditions. The deposits became patchy after 8 days, so no doubt large areas of the calf were of low toxicity to flies after that day.

TESTS WITH LINSEED OIL

Two preparations were made up.

(1) 81 per cent p'p' D.D.T. dissolved in commercial boiled linseed oil with gentle heat to give an 8.1 per cent p'p' solution.

(2) 81 per cent p'p' D.D.T. dissolved in raw linseed oil which was heated to 200 C. concentration of D.D.T. as above. The resultant mixture which may have contained decomposition products of D.D.T. was diluted with equal parts of kerosene when cold. The kerosene was added to reduce the viscosity for spraying.

Both solutions were tested on paddocked calves, as before, flies being exposed on the 4th, 8th and 14th day after treatment.

Rain fell as follows:—

Days after Spraying ..	1	2	3
Rainfall in mm. ..	1.5	1.8	5.0

Per cent mortality was never above 30 per cent though heavy deposits were visible up to day eight on the calf receiving solution. (1)

SUMMARY

Tests were carried out to determine the persistency of toxicity of various preparations, the preparations being applied at various dilutions to calves in covered stalls in one series and in the second series to calves exposed to natural conditions in paddocks. D.D.T. emulsions were superior to the dispersible powder, and in general the persistence of D.D.T. preparations was greater than those based on gammexane.

Coumarone resin added to a D.D.T. emulsion gave increased persistency. Linseed oil solutions gave a good deposit, but low toxicity.

Crystallization of D.D.T. occurs on drying the emulsion, but not the linseed oil solution, and this may account for the different toxicities.

Glossina palpalis fuscipes was the test insect, and was exposed for twenty seconds in every case.

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NOTES ON ANIMAL DISEASES

* XXI—DISEASES CAUSED BY WORMS—(PART I)

Compiled by the Veterinary Department, Kabete, Kenya

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All the parasitic worms of domestic animals in Kenya, except for leeches, belong to either the flatworms (*Platyhelminthes*) or the roundworms (*Nemathelminthes*).

The flatworms may be divided into two classes, the tapeworms (*Cestoda*) and the flukes (*Trematoda*). The parasitic roundworms are all members of one class, the *Nematoda*. Leeches belong to the *Annelida* or ringed worms.

Before detailing the more important parasitic worms of stock, a few brief notes on the causes and diagnosis of worm infestations will enable the reader to obtain a better appreciation of the problem and will avoid much repetition.

CAUSES OF WORM INFESTATION

Even domestic animals can harbour fairly large numbers of most worms before they show any signs of unthriftiness and some wild animals can have huge numbers of worms and still look healthy, which shows that it is only when the balance between the animal and its worms is upset by domestication or other adverse conditions that trouble is encountered. The zebra and the guinea-fowl are examples of wild animals which are always packed with worms and which appear to keep in excellent condition. Under natural conditions, however, animals are free to migrate and hence, except perhaps during very severe droughts, they are able to maintain themselves on the diet for which they became evolved. Once an animal is tamed, its environment is unnatural and restricted, and its diet may be very different from that for which it is fitted anatomically and physiologically.

In the free state, moreover, the energy derived from the food is expended on the maintenance of the animal and on reproduction at a rate suitable for the species. Domesticated animals, however, have to spend additional energy on work, either on mechanical work, such as that of work-oxen or riding-ponies, or on production, for example, of wool, milk or eggs. The supply of energy is limited by the functional capacity of the alimentary tract, and it is obvious, therefore, that waste through parasitism may upset the positive balance necessary for health. Most farmers see the necessity for feeding concentrates to racehorses and high-producing cows; few, however, realize that extra energy is also required to produce and carry a heavy Merino fleece.

Speaking generally, therefore, the reasons why domesticated animals suffer from worms are, firstly, the effects of heavy concentrations, and secondly, interference with the normal plane of nutrition. These points are important for they bear on methods of control.

Many instances could be cited of farmers who, having realized the advantages of keeping a small flock of sheep on their farms or a small number of poultry, have decided that running sheep or poultry is a simple and profitable proposition and have increased the numbers only to meet with disappointment. Losses in such cases are almost always attributable to worms and the explanation is usually easy to find. A small number of sheep or poultry around the homestead do not build up a heavy infestation of worm eggs or larvæ on the land; but when numbers are increased the land rapidly becomes fouled and special precautions must be taken if the stock are not to develop abnormally heavy worm burdens. A few sheep or poultry have ample choice of food: when many are present they may have to take whatever is available to satisfy their hunger. Restriction of choice, therefore, leads to disturbance of the nutritional plane. The reason for the disturbance may not be obvious. A patch of grazing, for example, may appear excellent to the human eye; but plants vary in their mineral and vitamin contents and it may happen that there are insufficient specimens of a certain type for all the animals to obtain their full requirements.

As sheep and poultry are farmed on a larger scale than other species, parasitic troubles are more frequent in them. The most important principle to observe is frequent movement. It is impossible to lay down any definite period after which a sheep fold should be moved. The safe time will obviously depend upon the number of sheep in the fold, the type of country and the season of the year, and it can be judged only by experience. Water supplies in East Africa are often difficult and it is sometimes the practice to move the sheep fold and grazing areas frequently, but to water the sheep at the same spot for a considerable period. Trampling causes the area around the watering place to become either soggy, if flat, or dry and bare, if sloping. In the former case, conditions ideal for the development and persistence of worm larvæ are produced, and in the latter the fouled earth is frequently treated as a salt lick. It is obviously desirable, therefore, to pay special attention to watering sites.

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*A revision of the article on this subject which appeared in this Journal Vol. IX, Nos. 3 and 4, 1944.

When keeping large numbers of poultry the runs should either be moveable or should be sufficiently numerous to allow of two being empty whilst one is in use. The former method is to be preferred, since the intermediate stages of some poultry worms occur in earthworms and other burrowing animals which are not eradicated when the ground is dug over.

Diagnosis of Worm Infestation

Symptoms.—The symptoms produced by parasitic worms depend on the habitat of the worms and on the numbers present. In the vast majority of cases the presence of a few worms causes little or no disturbance; in fact it is exceedingly difficult to maintain stock completely free from worms.

Each species of worm has its own habitat and the commonest sites to find adult parasitic worms are the alimentary tract, the liver and the lungs. The lungworms are rarely found in domesticated animals in Kenya except in sheep, and as infestation of this species has already been described in these notes, there is no need to mention them further.

The symptoms of worm infestation of the alimentary tract vary slightly with the different kinds of worms and the species of host; but they consist usually of unthriftiness and loss of condition ("razor-back"), watery swelling of the throat ("bottle-neck") and fluid in the thoracic and abdominal cavities ("pot-belly"). The coat is usually rough or shows irregular patches and the skin may be "scurfy". There is almost always some degree of anæmia; but pallor of the mucous membranes is particularly marked when large numbers of blood-sucking worms, such as hookworms, are present. Many species of worms cause diarrhœa and the fæces may be dark, rusty red in colour owing to the presence of digested blood.

Of the liver parasites, fluke is the only one to produce symptoms. The symptoms resemble those produced by blood-sucking strongyles in the alimentary tract.

Collection of worms.—Whilst the collection of parasites from sites other than the alimentary tract usually presents little difficulty, it is necessary to adopt the following method if a proper idea as to the numbers and species of forms present in the stomach and intestines is to be gained. It is recommended that all dead sheep be examined in this way as a routine, so that the farmer can keep himself informed as to the health of his flocks.

The fourth stomach, small intestine and large intestine are removed separately. The small intestine is straightened out into a bucket and hot water, as near boiling as feasible, is then poured through the intestine. Not more than about two pints are usually needed and the intesine is pulled upwards out of the bucket to allow the water to pass down the whole length of the gut. If the gut breaks or the water is getting cold the intestine may be broken off and some more hot water should be added. In this way all the worms are washed out of the intestine and may be collected by pouring the contents of the bucket through one or two sieves—one 20-mesh and one 30-mesh sieve are the most effective. The sieves are then washed in a basin of clean water and the worms may be picked out with a needle and counted. A hand lens will help in seeing the small trichostrongyles which will be found in the 30-mesh sieve. The large intestine may be treated in the same way but a greater quantity of hot water is needed.

The fourth stomach is filled with hot water from the end away from the small intestine. The pyloric sphincter prevents the escape of the water which, after rinsing round, is poured out. The worms are collected in sieves as for the small intestine. The fourth stomach can be examined almost as quickly by opening it in a little water and washing all the worms off the inner lining. If no hot water is available, the fourth stomach and intestines should be cut open separately into buckets or jars and pulled through the finger to remove all worms adhering to the walls. The worms may be collected in sieves as described above.

Many attempts have been made to obtain an estimate of the numbers and species of worms in the alimentary tract of animals by counting the eggs present in the fæces. Unfortunately no reliable method has been found. The number of eggs produced by worms seems to vary from day to day and the close resemblance between the eggs of many species makes identification unsatisfactory in most cases, unless cultural methods are used.

FLUKES

Flukes are unsegmented, parasitic flatworms. The life histories of those forms which are internal parasites are extraordinarily complicated. From the egg which leaves the definitive host a form known as a "miracidium" escapes. This swims about in water until it finds an appropriate host, usually a snail. It penetrates between the cells of the skin of the snail and continues until it reaches a particular organ, where it settles and grows and multiplies until minute, tadpole-like "cercariæ" are formed and these escape from the snail into the water. These may be swallowed by the definitive host, or they may encyst on vegetation and become resistant to desiccation until such time as they are swallowed. In the case of blood flukes, the motile "cercariæ" are capable of passing through the intact skin.

Only three groups need be considered here, the liver flukes, paramphistome flukes and the blood flukes.

Liver flukes.—Liver flukes occur in sheep and cattle, being probably more common in Kenya in the latter species. These parasites are flat, elongated, leaf-like animals, brown-grey in colour, and when mature are found in the bile ducts of the liver. Eggs pass to the bowel by the bile duct and are passed out in the fæces. The intermediate hosts are species of *Limnæa* snails, which favour stagnant water.

On post-mortem examination the bile duct walls are found to be greatly thickened and adjacent parts of the liver are pale in colour and fibrous. Cases of sudden death sometimes occur due to a sudden massive infection of sheep with fluke. In such cases death results from the extensive destruction of liver tissue by numbers of minute flukes or from infection of the damaged liver by a pathogenic anaerobe, *Clostridium œdematiens*. The latter condition is usually known as "black disease". Post-mortem examination shows bloodstained fluid in the abdominal cavity and a swollen, soft, hæmorrhagic liver.

There are now four drugs used in the treatment of liver fluke. They are carbon tetrachloride, extract of male fern, hexachlorethane and stibophen.

Carbon tetrachloride is quite satisfactory in sheep or cattle in Kenya though in Europe it is considered dangerous for cattle. The dose for sheep is 1 cc. (much less than is needed for hookworm) and for cattle 4–6 cc. This should be mixed with liquid paraffin or some other mineral oil, and should be immediately preceded by a dose of 10 cc. 2 per cent copper sulphate. A diet of carbohydrates and no proteins or fats given beforehand will help to eliminate the danger of dosing with carbon tetrachloride.

Extract of male fern needs to be very fresh to be effective and, as in this country it is difficult to ensure that the drug is fresh, it is very variable in its action.

Hexachlorethane mixed with bentonite to form a suspension has been widely used in America, but there are no stocks in this country and the little we have been able to obtain has proved unsatisfactory.

Stibophen has been used lately in this country with apparent success but it has so far not been tried in any controlled experiments.

No drugs are entirely effective against the immature flukes so that it is usually necessary to repeat the dose in 4–6 weeks.

Treatment should always be combined with measures to prevent reinfestation. Canalization of swampy watering places near springs is often successful and much can be done by keeping furrows and the edges of dams free from vegetation. The addition of copper sulphate to give a concentration of one part in 500,000 of water will kill off the snails.

Paramphistome flukes.—At least three paramphistome flukes are known to occur in the rumen of ruminants in East Africa. They are pale pink and pear-shaped, the largest species being about one inch long. Although they suck blood they are not of great importance though the immature flukes of one species, *Cotylophoron cotylophorum*, are sometimes present in great numbers in the early part of the small intestine when they may cause diarrhœa.

Blood flukes or Schistosomes.—These flukes appear to be rare in Kenya; but *Schistosoma bovis* has been collected on two or three occasions. The males are white in colour, about three-quarters of an inch long and have a groove along the ventral surface in which the thread-like female is carried. These parasites are found in the veins that drain the blood from the gut. Eggs are deposited in numbers in the capillaries of the gut wall which they block. They penetrate through the gut wall into the rumen and are voided in the fæces. The intermediate hosts are snails of the genera *Bulinus* and *Physopsis*.

TAPEWORMS

Tapeworms, as the name implies, are long, flat and white. They are segmented and multiply by producing more and more segments. The segments at the end are the oldest and when these are ripe and full of eggs they fall off, and pass to the exterior in the fæces. If after a short period they are swallowed by a suitable intermediate host, they pass to the body cavity, organs or musculature, where development and, with some species, multiplication occur. The larval stages remain in the intermediate host until ingested by the definitive host. In the intestine of the definitive host the larva develops into a tapeworm.

As the larvæ in the intermediate hosts are usually embedded in the muscle or attached to the mesentery and not in connexion with either the blood stream or the alimentary tract, it has so far proved impossible to kill them. The chief control measures, therefore, are to kill the adult in the final host or to prevent the final host eating the intermediate host or (in the case of human tapeworms) to prevent the intermediate host becoming infected.

Tapeworms of carnivores.—The commonest tapeworm of dogs in Kenya is *Dipylidium caninum*, sometimes known from the appearance of the segments as the "cucumber-seed tapeworm". The larval stage occurs in fleas and biting lice. Other species which have been found are *Mesocestoides lineatus*, the life-cycle of which is not known with certainty, *Tænia hydatigena*, the intermediate stage of which is known as *Cysticercus tenuicollis*, the large bladder worm found in the peritoneal cavity of sheep and other herbivores, and a species of *Diphyllobothrium*.

Cestarsol or arecoline hydrobromide are very effective in the treatment of tapeworms in dogs. Cestarsol is probably rather safer. The dose of cestarsol is to be found on the bottle and for arecoline hydrobromide it is from $\frac{1}{8}$ to $\frac{1}{2}$ grain—about $\frac{1}{8}$ grain per 10 lb. body-weight.

Hyæna and lion harbour species of *Tænia*, the intermediate stages of which occur almost certainly in ruminants. A related genus *Echinococcus* must occur in carnivores in East Africa, for whilst the very small adult worms have not been collected, the large metacestode stage, the so-called "echinococcus cyst" is found not infrequently in the liver or lungs of cattle and sheep.

Tapeworms of man.—Of the tapeworms of man, *Tænia saginata* and *T. solium* call for mention, since their intermediate stages are the so-called "measles" of cattle and pigs respectively.

Except for the treatment of man, the chief methods of control are by providing and insisting on the use of sanitary latrines for all African labour and by cooking all meat thoroughly.

Tapeworms of herbivores.—The tapeworms of horses, cattle and sheep belong to the family Anoplocephalidæ. The life-cycle of the members of this family was for long a mystery; but it is now known that the larval stage of several, including the common *Moniezia expansa* of sheep, goats and cattle, occurs in small free-living mites found on pastures.

One species, *Stilesia hepatica*, is found in the bile-ducts of the liver of sheep. It produces some thickening of the walls of the ducts, but is not responsible for serious symptoms.

Species of *Moniezia*, *Thysaniezia*, *Avitellina* and *Stilesia* occur in the gut of ruminants and a heavy infestation of weaner lambs leads to loss of condition and may cause mortality. A specimen of *Moniezia expansa* may attain a length of over six yards.

Treatment of tapeworms in lambs cannot be regarded as entirely satisfactory. Fresh male fern extract is effective but expensive. Nodular worm remedy often gives good results. Copper sulphate and nicotine drench is perhaps less effective, but is cheaper. The mixture is prepared by taking 30 cc. of 40 per cent nicotine tobacco-extract, 30 grams of copper sulphate, and dissolving them in 1,800 cc. of soft water. The dose for lambs and kids is 15–45 cc., for calves 30–100 cc. The dose should be given before allowing to feed in the morning. It should be followed by a dose of castor oil and the lambs should be shut up for a further two hours before being turned out.

Two species of *Anoplocephala* are found in horses, mules, donkeys and zebra. They appear to be of no significance.

No adult tapeworms occur in the domestic pig, although both the wart-hog and bush-pig have their own particular types.

Tapeworms of poultry.—At least nine species of tapeworms have been found in the domestic fowl in Kenya. The most important of these are *Amœbotœnia sphenoides, Davainea proglottina* and *Raillietina tetragona.* Of these, the first two are so small that their presence will not be detected unless special search is made. The inner lining of the duodenum (the U-shaped loop adjoining the gizzard) should be scraped with the point of a penknife and the scrapings placed on a glass slide. A large drop of water should then be added and another slide placed on the top. On squeezing gently and holding up to the light *Amœbotœnia sphenoides* appear as triangular bodies, $\frac{1}{8}$–$\frac{1}{4}$ of an inch long, denser and whiter than the teat-shaped villi removed from the mucosa of the gut. *Davainea proglottina* are slightly longer and narrower at the base. When causing symptoms, such as loss of condition and pale combs, these parasites are, of course, present in large numbers. *Raillietina tetragona* measure up to 10 inches in length. Although little thicker than a hair anteriorly, the wider, posterior segments are easily seen. The head of this species penetrates the inner layers of the gut wall and produces small nodules, visible from outside the gut. The larval stages of *Amœbotœnia* are found in earthworms, of *Davainea* in slugs and of *R. tetragona* in maggots.

The best method of treatment appears to be the administration of $\frac{1}{4}$ to 1 cc. of turpentine diluted with a little bland oil to each bird by stomach tube followed by Epsom salts in the mash.

FURTHER NOTE ON ONION EXPERIMENTS ON KILIMANJARO

By R. J. M. Swynnerton, M.C., Agricultural Officer, Tanganyika

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The results of the 1947 series of onion experiments carried out on Kilimanjaro, a continuation of those recorded in the *East African Agricultural Journal* for January, 1947, are submitted here as it will probably be necessary to discontinue them for the present on account of staff changes. The writer warmly acknowledges the assistance rendered in his absence on leave by Messrs. H. L. Brett and J. S. Gunn, Agricultural Officers, the former in harvesting the experiments, the latter for undertaking the statistical analyses.

The onion season of 1947 was notable for the early onset of rain and a precipitation above the average in the months of main rainfall, April and May. The overall mean yield of the experiments was 6.77 tons, the variety of onion grown again being Bombay Red. The experiments were planted in three different areas, Msaranga, an early planting area in the dry lowlands; Uru, an area where onions are normally transplanted at the onset of the rains; and Machame West, a wet area where the onions were planted in the height of the rains. While the experiment planted in the last-named area failed to produce the results hoped for from the application of sulphate of ammonia, the rainfall was such that it was probably washed out of the soil too rapidly to be of great benefit to the onion plants, which were more affected by the subsequent water-logging. This may be why, contrary to previous experience, the heaviest application of sulphate of ammonia, 6 cwt. per acre at Machame West, gave the highest yields in that experiment. While the water supply to the onion beds can be controlled in dry weather under irrigation, the application of sulphate of ammonia during spells of heavy rain may be inadvisable and it may be preferable to vary the time of application to coincide with a break in the rains when light applications of sulphate of ammonia will give the best and most economic results. This aspect requires further study.

The two principal trials were laid down as 3 x 3 x 3 fully confounded factorial experiments, one transplanted on the 12th February at Msaranga on land which had been fallowed for some years previously, the other on the 8th April at Uru on land which had previously carried maize. The factors tested were the spacing between onion rows, the rate of application of sulphate of ammonia and the time of its application. In the case of the Msaranga experiment, the manurial treatments had all been applied before the onset of the particularly heavy rains in April. At Uru the first application of sulphate of ammonia was made at the height of the rain, the two later ones in May as the rains decreased. The results are recorded in Table II in the form of tons of dry onions per acre. The treatments will be discussed separately but, as must be expected from the nature of the experiments, interaction between treatments will be noted where it has been found to be a significant factor. In interpreting the effects produced by the rate

TABLE I

Rainfall at Moshi in inches

	1942	1945	1946	1947	Mean of 37 years
February ..	0·00	0·58	0·43	1·32	1·99
March	14·39	4·04	0·54	4·35	4·54
April	13·54	4·21	12·95	17·34	13·80
May	13·23	8·90	2·91	8·08	9·13
June	0·08	0·31	0·03	4·33	1·61

TABLE II

SPACING × RATE × TIME OF APPLICATION OF SULPHATE OF AMMONIA

	Tons of Dry Onions per Acre	
	Experiment I	Experiment III
	Msaranga	Uru
A. SPACING—		
4½" between rows	7·94	7·85
6" between rows	6·43	7·01
7½" between rows	6·22	6·79
B. RATE OF APPLICATION—		
1½ cwt. S/A per acre ..	7·18	6·89
3 cwt. S/A per acre ..	6·93	7·57
4½ cwt. S/A per acre ..	6·48	7·18
C. TIME OF APPLICATION—		
15 days after transplanting	7·38	6·69
30 days after transplanting	6·73	7·64
45 days after transplanting	6·49	7·31

and time of application of sulphate of ammonia, it must be borne in mind that throughout the series of experiments a close spacing of onions in rows 4½ in. apart has consistently produced the heaviest yields of saleable bazaar type onions from the Bombay Red variety.

Spacing.—In both experiments, where spacing within rows was constant at 4½ inches, the close spacing of 4½ inches between the rows was very markedly superior in yield either to 6 inch or 7½ inch spacings, while between these two the difference in yield was of no significant importance. This fully confirms the results of previous years.

Rate of Application of Sulphate of Ammonia.—At Msaranga the application of sulphate of ammonia at the low rate of 1½ cwt. per acre was quite adequate (having in previous years and in experiment IV below been shown to raise yields markedly over no application of sulphate of ammonia). Increases in the application of sulphate of ammonia above this rate significantly decreased yields of onions. At Uru, on the other hand, the application of 3 cwt. per acre was superior to the lower and the higher rate. At Machame West (Experiment V) sulphate of ammonia applied during the April period of high rainfall indicated, though not significantly, that higher rates of application gave the greater yields.

Time of Application of Sulphate of Ammonia.—At Msaranga a very significant decrease in yield was shown to result from the application of the sulphate of ammonia later than 15 days after transplanting, the decrease being significantly greater 45 days after transplanting than 30 days after. At Uru the application of sulphate of ammonia 30 days after transplanting was superior to the earlier or later application. These results, while indicating that applications up to 30 days after transplanting, provided no check to growth has occurred in the seedling nursery, are beneficial, but later applications should be avoided. Further information on this factor is required. That there is a date beyond which it is not economic to apply sulphate of ammonia is confirmed by the results of Experiment II in 1947 at Msaranga. This experiment was laid out as a 6 x 6 Latin square to test various sprays against onion thrips. As no thrips appeared, sulphate of ammonia was applied 56 days after transplanting at rates varying from 0 to 5½ cwt. per acre, but yields from treatments and control varied little from the mean yield of 7.83 tons per acre. In Experiment V at Machame West, although results were not significant, the trend of yields indicated the advisability of splitting the applications of sulphate of ammonia, half being applied 15 days and the remainder 30 days after transplanting.

INTERACTIONS

At Msaranga there was a significant interaction between the spacing and the time of application, the time of application of sulphate of ammonia being less important at the 4½ inch spacing than in the case of the 6 inch and 7½ inch spacings, where the early application of sulphate of ammonia 15 days after transplanting had the most marked effect. This interaction was significantly reversed at Uru, the later applications (30 and 45 days after transplanting) producing the higher yields at the wider spacings. Here, however, the time of application was not so important when the 4½ inch spacing was employed as with the wider spacings. Further information is therefore required on the time of application of sulphate of ammonia, particularly in relation to rainfall.

At Msaranga there was also a significant interaction between the spacing and the rate of application of sulphate of ammonia, the 4½ inch spacing again being superior. The rate of application of sulphate of ammonia is not of great importance theoretically, provided the 4½ inch spacing is adopted, but economically it is unsound to apply more than 1½ cwt. per acre, since no further increase in yield was forthcoming. This finding was confirmed at Uru, the 4½ inch spacing making better use of the heavier rate of application of sulphate of ammonia than the wider spacings. Table III indicates that, on the Uru results, the heavier applications may be justifiable as economic considerations are favourable, the price of sulphate of ammonia being taken at Sh. 20 per cwt. and onions valued at Sh. 3 per frasila of 16 kilos.

TABLE III

4½ INCH SPACING × RATE OF APPLICATION OF SULPHATE OF AMMONIA

Rate of Application of Sulphate of Ammonia	Yield of Dry Onions per Acre			
	Experiment I		Experiment III	
	Tons	Sh.	Tons	Sh.
1½ cwt. per acre	8·22	1,540	7·20	1,350
3 cwt. per acre	8·59	1,610	8·02	1,500
4½ cwt. per acre	8·22	1,540	8·35	1,566

SILICOPHOSPHATE FERTILIZER

Although there are no major deficiencies in soil constituents in the fertile lava soils of Kilimanjaro, a request was received to try out silicophosphate on onions. A small experiment (Experiment IV), incorporating silicophosphate and sulphate of ammonia, was laid down at Uru on land planted to maize for several years previously. This silicophosphate was applied at the time of transplanting, the sulphate of ammonia two weeks later, each at the rate of 2 cwt. per acre.

TABLE IV

SILICOPHOSPHATE × SULPHATE OF AMMONIA

Tons of dry onions per acre

Sulphate of Ammonia (cwt. per acre)	Silicophosphate (cwt. per acre)		Mean
	0	2	
0	4·86	4·95	4·90
2	6·69	6·75	6·72
Mean.. ..	5·77	5·85	5·81

Silicophosphate at 2 cwt. per acre produced no significant increase in yield of onions either in combination with sulphate of ammonia over plots treated with sulphate of ammonia alone or over untreated plots. On the other hand, sulphate of ammonia very significantly increased the yields as compared with untreated plots, the increase amounting to 37 per cent. Naturally, it is dangerous to draw conclusions from the results of only one experiment in only one year on Kilimanjaro soils.

THRIPS RESISTANCE

As one of the lines of investigation of a means to combat onion thrips, which in dry years ravages the onion crop, a variety of onion, by name Texas Grano, reputed in the United States to be resistant to thrips, was found to be highly susceptible in a year of low infestation when the Bombay Red variety produced fair yields.

CONCLUSIONS

On flat Chagga beds, with the Bombay Red variety of onion, a close spacing of 4½ inches between rows of onions, has persistently over a period of years been found to be very much superior to wider spacings.

Low rates of application of sulphate of ammonia of the order of 1 to 2 cwt. per acre may usually be expected to make substantial and economic increases in yields of onions over untreated plots. With close spacing, higher rates of application are also economic, and may be advisable if applied during wet weather.

An early application of sulphate of ammonia, in any case within 30 days of transplanting, may be expected to raise yields of onions appreciably, later applications showing little advantage over untreated plots. It is probably better to apply the sulphate of ammonia in two instalments at 15 and 30 days after transplanting, at the same time avoiding periods of heavy and continuous rainfall. Further information is required on these points.

Provided 4½ inch spacing is used, higher rates of application of sulphate of ammonia are likely to be economic and the time of application is less important.

Under the conditions of one year, 1947, and in the soils of Kilimanjaro, silicophosphate effected no increase in the yield of onions over untreated plots.

The variety Texas Grano, introduced from the United States, was found to be highly susceptible to the attacks of onion thrips.

PASTURE MANAGEMENT

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The term "pasture management" is now frequently used in everyday conversation, yet the solution of this problem is not always as easy as it may sound. One is often asked the question: What exactly do you mean by "pasture management" and how should one set about the task?

The principles of pasture management are complicated and become obscured by local conditions such as climate and soil. Periodic waves of enthusiasm which generally accompany the introduction of "new" pasture plants may have had beneficial effects in the past, though in certain respects they have been detrimental to progress in pasture management. For the greater part these "wonder pasture plants" disappear after a few seasons when they are replaced by coarse, rank-growing, fibrous species, unless the latter can be kept in check by cultivation, mowing or by some other form of control. A mowing machine is a very good investment on the farm, and the nature of the herbage can be changed to a considerable extent. It may even be improved to such a degree that the quality would compare favourably with the feeding value of introduced fodder plants. Good results in this respect have been obtained in parts of South Africa where grass which was normally allowed to grow rank and become unpalatable was mown frequently while still succulent and nutritious.

As regards new introductions the following paragraph quoted from "Advances in Grassland Husbandry and Fodder Production" [2] may be of interest: "At present much attention is being given to pasture grasses and there is a general belief that this is a new development. It is, however, a revival of an old scheme, for as early as 1904 some 25 species or varities of grass were imported for trial at Potchefstroom. All the grasses except species of *Paspalum* quickly died out. In 1910 a collection of 40 indigenous types was therefore made, and of these two have survived and proved useful, namely, *Chloris gayana* and *Cenchrus ciliaris*."

My plea is not against new introductions but for better use of indigenous species. It is essential that we should have a clear picture of what veld management entails and how we can set about these problems in order to get the best possible use from the land without allowing deterioration. Pasture management is an ecological problem to a very large extent. Certain plant species and vegetation communities react differently to different treatments. Firstly, therefore, one has to decide which would be the most desirable and profitable vegetation type under any particular set of conditions and then to find the best treatments to maintain the desired type at its highest level of productivity. To quote again from "Advances in Grassland Husbandry and Fodder Production" [2]: "Saunders maintains that research in veld management should be directed not so much to finding what practice will give the highest yields of beef or wool, but to determining what system will restore a good vegetal cover. Other benefits would follow this as a matter of course."

In pasture management it is not possible to lay down hard and fast rules which can be adopted throughout, although the basic principles remain the same. Each area has its own peculiar problems, and pasture management, like other farming activities, calls for considerable initiative. The question which is so often asked: "What is the carrying capacity of this or that pasture type?" should be changed to read: "What carrying capacity can reasonably be expected under certain conditions where a specific system of management is applied?". Furthermore, there is no fixed carrying capacity figure for any given type of pasture, as it varies within certain fairly wide limits. It is exactly what the farmer makes it, though even under the very best conditions of management a wide margin for safety is required in order to be able to cope with unexpected adverse conditions outside his immediate control.

PASTURE UTILIZATION

Grasses cannot tolerate continuous defoliation, and require periods of rest when they can develop their root systems, build up food reserves and form seed. Continuous defoliation prevents these processes from taking place, causing rapid exhaustion and death of the plants. In mixed pastures where selective grazing takes place the palatable species are generally the first to suffer, and they are soon ousted by coarse undesirable plants. This is very common in some of the Highland areas of East Africa and is particularly noticeable in parts of the Mbulu district of Tanganyika and in the Kenya Highlands where Red Oat Grass (*Themeda triandra*) has been replaced by a coarse "wire grass" (*Pennisetum schimperi*) over extensive areas.

Pasture deterioration is usually caused by over-grazing, but it may also result from under-grazing when vigorous growth ceases and some of the desirable species are smothered and replaced by undesirable plants. Prolonged under-grazing of pasture which is not burnt or mown causes "growth stagnation". Such treatment also results in an increase of weeds and woody growth, and the deterioration of the grass cover is most noticeable after a fire has swept over such an area.

Seasonal protection generally gives better results, though it depends to a large extent upon the time of the year and upon local conditions. A theory which was very popular at one time, namely, that protection during the early growing season is essential, has now been exploded, and it has been found that in many cases it is not so much protection that is required during the early growing season but fairly heavy grazing in order to check the rapid growth of annuals and various coarse undesirable species. If allowed to grow unhampered at the beginning of the growing season these early growers tend to smother the more desirable plants, including the matting types which generally provide the most suitable permanent cover.

Pasture utilization therefore requires a rest period during the most suitable time of the year in order to enable certain plants to develop, but some grazing is required throughout the year, and this leads us to the next question of the desirability of rotational grazing and control.

ROTATIONAL GRAZING AND FENCING

The best way of protecting a pasture against over-grazing is to adopt a system of rotational grazing. In this the land is sub-divided in such a way that the animals graze only on a restricted area during any one time while the pasture on the rest of the land is given an opportunity to grow unhampered. The animals are periodically moved from one section of the farm to another in suitable rotation. Under such a system a larger number of stock would be concentrated on a given area for a relatively short period and the harmful effects of selective grazing under extensive conditions would be minimized considerably. It is very noticeable that when animals are frequently changed from one field to another they eat a much greater proportion of the total herbage than when they have access to a large area. Furthermore, the intermittent rest periods also give the more palatable species a better chance to recover than when grazed continuously.

Grazing control is complicated by scarcity of water, and it is often necessary to herd the animals or to use hedges, although the latter are seldom really stock-proof. Fencing plays a very important part in grazing control and if carried out effectively it can improve the carrying capacity of farms to a very great extent.

MOWING OF EXCESS HERBAGE AND CONSERVATION OF DRY-SEASON FODDER

During the rainy season plant growth is rapid, and there is generally more food than the animals can consume, but during the dry season there is practically no growth and they have to exist largely on dried-out fibrous residues. Excess growth should therefore be cut and stored for using when food supplies are inadequate. This would not only mean that supplementary food supplies are available when these are most urgently required, but the pasture itself would greatly benefit from the removal of rank-growing plants. Such treatment would therefore result in an improvement in food supply yielding a better quality herbage consisting of less bulky fibrous growth, and a denser sward giving more protection to the soil. A pasture can be maintained in such a desirable condition by rotational grazing, mowing, or cutting by hand. These treatments would also reduce weed growth to a considerable extent and would eliminate a number of plants which otherwise would tend to become troublesome. In some cases burning may have to be resorted to, but in spite of what is said about burning being able to control ticks and provide early—and late-season—succulent growth, it cannot be recommended for regular practice. It should be done as seldom as possible.

It is essential that adequate supplementary food should be supplied during the scarce periods in order to get most benefit from pasture control. A great deal of damage is done to pasture during such periods when there is little food and, furthermore, there is a considerable loss due to decreases in animal weights and milk yields.

SOIL FERTILITY AND CLIMATE

The type and quality of pasture that can be produced depends to a large extent upon the soil and climate as well as on management: a poor soil can only produce a relatively poor pasture.

The use of artificial fertilizers on pastures in East Africa from a practical point of view is still an untouched field and apart from trials on an experimental basis it is not used much in general farming. The same also applies to compost and to some extent farm-yard manure; the main disadvantage regarding the latter, however, is the difficulty of transportation and the relatively heavy applications which are necessary. This means that only comparatively small areas can be treated and on the whole it is not an economical proposition. Farm yard manure can be far better used on intensively farmed land and for gardening.

There are also other factors to be considered in soil fertility problems. Erosion control and a soil stabilized by a dense vegetation cover have many advantages and allow for increased moisture, increased growth, a longer growing season and the retention of fertile soil particles.

Management with all its different aspects is the first essential problem to tackle before much can be accomplished by improvements in some other directions and unless these basic items can be solved satisfactorily it would be difficult to grow two blades of grass where one grew before.

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SOIL PHOSPHATES—A REVIEW OF THE LITERATURE

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The vast amount of literature on the subject of soil phosphates testifies not only to the importance of phosphates in agriculture but also to the difficulties that have been encountered in interpreting their behaviour in soils. This is understandable when one considers the number of forms in which soil phosphates occur and the number of factors that affect their solubility. The volume of literature on this subject appears to be increasing annually, possibly because more recent investigations have done much to clarify the problem and have therefore acted as a stimulus to those engaged in this particular branch of soil science.

In an attempt to systematize the large number of observations that have been recorded, the literature from about 1935 to the present has been reviewed. Most of the publications pertinent to the subject were found in Soil Science and Soil Science Society of America Proceedings. Other journals were, however, consulted, while Soils and Fertilizers gave concise abstracts of papers, some of which are not available here. To preserve the continuity of the following article all references to authors and journals have been omitted from the text, but a relevant bibliography has been appended. Moreover, those references have been selected from the original bibliography that are related to the practical rather than the more fundamental scientific work. This course was adopted in the belief that this article would then be of some interest to those concerned with the application and behaviour of phosphates in the field.

ACID SOILS

Acid soils and those containing hydrated oxides of iron (red and yellow soils) present special problems in phosphate fertilization. In such soils the hydrated iron oxides and/or the clay minerals "fix" phosphate by a process of absorption, often to such an extent that it is unavailable to the plant, or too slowly available to be of much value for growth. It has, indeed, been reported that soils of this type all require phosphate fertilization. The capacity of such soils to fix phosphate depends on the content of clay minerals and hydrated iron oxides (aluminum oxides are less important) and also on their acidity; and an illustrative example of the behaviour of three lateritic soils (soils characterized by an excess of hydrated iron and aluminium oxides) may be here cited. With an acid clay loam (pH 4.7) maximum responses to phosphate fertilization were not obtained until an application equivalent to 8,000 lb. of 20 per cent superphosphate per acre had been made. A slightly more acid sandy clay loam (pH 4.5), i.e. a coarser textured soil, required 2,000 lb., while with a less acid, fine, sandy loam (pH 5.9) maximum response was obtained with less than 1,000 lb. As a result of this work it was suggested that excessive quantities of soluble phosphates must be applied to acid soils in order to maintain a high level of weak acid-soluble phosphorous (i.e. available to plants). The work also indicated that the more firmly fixed (absorbed) phosphates are absorbable by plants but too slowly to be of much value for growth.

It is clear that, depending on the acidity of the soil, its texture (which is a reflection of its clay content) and the amount of hydrated iron oxides, normal applications of superphosphate, e.g. 50–100 lb. per acre may or may not be effective. With sandy soils of low fixing power repeated small doses of soluble phosphate should be applied with water during the growing season to minimize the heavier losses that would occur by leaching if all the phosphate were applied at once. For soils of high-fixing power heavy applications of phosphate are essential. On such soils normal applications may be completely wasted since the entire amount may be fixed in the surface inch or two, while larger applications may be uneconomical. There are, however, several practices by which the phosphate fixing power can be reduced with a consequent saving in the amount of fertilizer that has to be applied. Effective methods are liming, correct fertilizer placement, pretreatment of seeds, the use of manure and the use of silicates. These are dealt with briefly in turn.

There is overwhelming evidence that the liming of soils in conjunction with phosphate fertilization is highly beneficial. Preparatory liming assures substantial conversion of superphosphate to the readily available form of dicalcium phosphate and at the same time greatly reduces the power of the soil to fix phosphates by absorption. The general consensus of opinion is that soils should be limed to pH 6.5, i.e. slightly on the acid side of neutrality. Podsol soils, which have compounds of iron and aluminium in the very acid B horizon, call for ploughing under liming materials. In all cases over-liming should be avoided, this is dealt with more fully later. It has been reported that "nest" application of lime and phosphate, i.e. localized zones of lime and phosphate, on strongly phosphate fixing sub-tropical red soils is far more effective than when lime and phosphate are evenly distributed through the soil. The balance of opinion for and against this practice is however such that one cannot afford to be dogmatic.

Fertilizer placement is important. Line application within the root zone, in bands near the seed and in the plough furrow are recommended. The use of coarse pellets instead of finely-divided superphosphate is also effective because diffusion of the phosphate, and therefore fixation, is decreased. Another practice is to combine fertilizing and seeding in one operation. Compared with broadcasting the phosphate this method saves labour, reduces weed growth and phosphate fixation and causes better establishment of the crop and earlier growth and ripening. Up to 3 cwt. per acre of superphosphate can be combined with cereal seed under normal soil and weather conditions with no risk of injury to germination; 1½–2 cwt. is usually enough. For root crops generally, sowing seed and fertilizer together is risky, but superphosphate at not more than 2 cwt. per acre may be combine drilled with seed on phosphate-deficient soils. Under dry conditions and on land not seriously deficient in phosphate it is best to broadcast the fertilizer. Sowing peas and beans in direct contact with any fertilizer is always risky. Grass and clover seed mixtures show marked response to combine drilling with 3 cwt. per acre of superphosphate on phosphate-deficient land. Up to 3 cwt. per acre of a mixture of phosphate and nitrogenous fertilizers may be combine drilled with cereals provided it does not contain more than 1 cwt. of ammonium sulphate. For all crops other than cereals it is generally safer to broadcast fertilizer mixtures.

Some interesting work has been published on the pretreatment of seeds. Striking increases in wheat yields were obtained by soaking the seed in half its weight of a 5 per cent solution of dipotassium hydrogen phosphate and then drying at 22° C. The result of greatest potential practical importance was obtained on oats. The yield was increased from 17 to 25 cwt. per acre at a cost of 13.6 lb. per acre of potassium phosphate which is equivalent to 4.6 lb. of P_2O_5.

While the beneficial effect of organic matter in reducing phosphate fixation is doubtful, there are several references to the value of manure. Apparently the manure exerts a protective effect upon the soil mineral colloid, thus reducing its fixing power, and/or replaces phosphate already fixed. The beneficial effects recorded were not due solely to the nutrients supplied by the manure.

Sodium silicate applied to a very acid heavy clay soil was reported to produce a growth without phosphate fertilizer almost equal to that on the phosphate fertilized soil. The mechanism here is that the silicate ions replaced the absorbed phosphate ions thereby making them available to the plant. Silicophosphate has, on occasions, been found to be superior to superphosphate on some East African soils and it is quite possible that this superiority is due to the silicate in the silicophosphate. The silicate either replaces the absorbed phosphate or is itself absorbed in preference to phosphate. Probably the two reactions are simultaneous, their overall effect being to increase the efficiency of silicophosphate on acid soils. Reports from England indicate that on acid soils in wet regions silicophosphate is more available than super.

Superphosphate plays by far the largest role in phosphate fertilization and it is not surprising that soluble or superphosphates have, so far, been prominent in the text. There is little doubt however that much of what has been written is also applicable to silicophosphate, which breaks down rapidly in water and moist soils liberating phosphate ions which behave in the soil in much the same way as those derived from superphosphate.

The use of rock phosphate on acid soils is worth considering, but there are many difficulties and disappointments attendant upon its use. Its value is derived principally from long-time use, and large applications (possibly a ton or more per acre) may, with time, approach the effectiveness of superphosphate. Large applications are necessary to satisfy the phosphate absorption capacity of the soil, and only over a long period (a year or more, depending on the acidity of the soil) does the rock phosphate change to a more soluble or available form. Immediate responses, following the application of rock phosphate, cannot normally be expected, and soluble phosphate should also be applied to give the young plants a quick start.

Among other factors that determine the response to rock phosphate applications are the crops grown and the type of rock phosphate used. It is reported that crops which take up large quantities of calcium normally feed well on rock phosphate, whereas crops like oats, millet and corn, which are poor calcium feeders, require acid conditions before the phosphate can be utilized. Also, although there is a tendency for the availability of phosphate in phosphate rock to increase with an increase in soil acidity there is a general trend, regardless of the degree of acidity, for the availability of phosphate in the rock phosphate to decrease as the percentage of fluorine in the rock increases. Only rock phosphate low in fluorine should be used as a direct phosphate fertilizer.

The slow availability of rock phosphate (the availability depends on a high degree of soil acidity), the depressive effect of any fluorine present and the variable responses obtained with different crops indicate why disappointing results are so often obtained following the use of this fertilizer. In alkaline soils its value is even less. Its behaviour under these conditions is discussed later.

Calcareous, Neutral and Alkaline Soils

Broadly speaking, most soils with a low phosphate fixing capacity are dark and many contain lime and plentiful organic matter, while those with the higher fixing power are acid soils and the red and yellow earths. In the latter group the naturally occurring phosphate is largely in the absorbed form, insoluble in dilute acids and difficultly available to plants, especially if the phosphate absorption capacity of the soil is largely unsatisfied. Applied phosphates are similarly fixed by a process of absorption. In calcareous soils the source of the naturally occurring phosphorous is usually a calcium phosphate type of complex of low solubility but capable of releasing phosphate ions, under normal soil conditions, more readily than the absorbed forms described above. Fixation of applied phosphates, by absorption, is not serious in these soils and phosphate fixation, when it occurs, is due to a different mechanism. Generally speaking the agent chiefly responsible for fixation in these soils is calcium when it is present in excess and in such forms as the carbonate, hydroxide, fluoride and sulphate. While in the acid types of soils discussed previously phosphate fertilization is invariably necessary, with calcareous soils this is by no means the case. Whether or not fertilization is necessary depends largely on the calcium status of the soil and the forms in which the calcium salts occur.

The concentration of calcium in the soil solution determines the capacity of the soil to release its naturally occurring phosphate. When the calcium concentration is reduced, through absorption by the plant or after rains or irrigation, there is an increase in phosphate concentration in the liquid phase. In a calcareous soil which does not require phosphate fertilization the conditions are such that the calcium concentration can be sufficiently reduced to permit an adequate supply of phosphate to become available. In other soils the calcium concentration of the soil solution may be so high (e.g. a result of the presence of gypsum) that the plant is unable to lower the calcium concentration sufficient to permit an adequate supply of phosphate.

The application of phosphate may therefore be necessary on many soils of a calcareous nature. For reasons discussed later rock phosphate is not normally effective on these soils and one is restricted to the use of the more soluble phosphates. When superphosphate is incorporated with either an adequately prelimed soil or one naturally calcareous the water soluble monocalcium phosphate is rapidly converted to dicalcium phosphate and this, slowly, to tricalcium phosphate. This succession is in the inverse order of solubility and the availabilities of these phosphates to growing plants. The dicalcium phosphate, though not water soluble to anything like the extent of monocalcium phosphate (the phosphate carrier in superphosphate) is highly available to plants. The tricalcium phosphate is less available, but the ultimate conversion of superphosphate to the tricalcium phosphate does not mean a serious loss of available phosphate. The disadvantage of tricalcium phosphate formation is that this compound, unlike dicalcium phosphate can be converted in the soil to such relatively unavailable forms as calcium fluorphosphate or calcium carbonate phosphate. Moderate preliming of a superphosphated soil is conducive to the desired formation and persistence of dicalcium phosphate. Excess liming or a calcareous soil promotes the transition of that phosphate to tricalcium phosphate which, as a result of the fluoride contained in the soil, the superphosphate, or the added lime, forms the insoluble and relatively unavailable calcium fluorphosphate. The term "relatively unavailable" is used because although this fluorphosphate is almost insoluble it is more soluble, as a result of the process by which it is formed, than the geologically formed mineral calcium fluorphosphate.

The formation of the fluorphosphate is one of the principal means by which phosphate fixation takes place in calcareous soils. The formation of the carbonate phosphate from the tricalcium phosphate is another cause, but as each of these reactions is very much slower than fixation by absorption (acid soils), and depend on the soil being markedly calcareous, or overlimed, it is clear why calcareous soils give less trouble than the acid group when phosphates are applied. Fixation, for instance, may take place only after the plant has obtained an adequate supply of phosphorus.

An ideal soil for the reception of superphosphate is one which in the natural state, or as a result of preliming, has its acidic and phosphate fixation properties neutralized. In neutral and, more especially, basic soils (whether naturally so or as a result of overliming) there is an increasing danger of fixation by the type of reactions described above especially at pH 7.6 and over. High alkalinities, or calcium contents, are also detrimental in that they depress the solubilities of iron, manganese and boron. Further, a high content of calcium carbonate, by interaction with the carbonic acid in the soil, can depress the reaction whereby tricalcium phosphate is converted by the carbonic acid liberated by the plant roots into a more soluble form.

Effective treatment of alkaline calcareous soils in which fixation is likely to occur appears to be restricted to the use of organic matter and manure. This is attributed to the liberation of carbon dioxide which increases the solubility of the phosphates by favouring the formation of dicalcium phosphate, which is available to the plant. Insufficient carbon dioxide in these soils can be a growth-limiting factor. Anoher advantage of manure is that it greatly aids in deeper penetration of phosphates.

The reason why rock phosphate may sometimes be of value on acid soils is that the latter cause the rock phosphate to change slowly to a more soluble form. The more acid the soil the more likelihood there is of such conversions taking place. When applied to alkaline soils the solubility of the rock phosphate is so low as to make it practically ineffective. Moreover, ground rock phosphate, even if it were practically pure tricalcium phosphate, is not to be compared physically with the tricalcium phosphate that results in the soil as a product of superphosphate reversions. Similarly with fluorphosphate (derived from incorporations of superphosphate) and apatite (the geologically formed mineral calcium fluorphosphate). The solubility of the reverted form exceeds that of the natural form.

Before leaving the subject of rock phosphate it should be mentioned that, lacking alternative sources of phosphate, there are some practices that may be of value in making it more available. It has been shown that under farm conditions ground phosphate rock can be converted, in part, to a more available form by composting with manure and sulphur. In such a compost the sulphur oxidizing organisms convert the sulphur to sulphuric acid which acts upon the phosphate rock and converts a part of it into an available form.

Another method is to use such crops as rape or sweet clover, which feed relatively well on rock phosphate, as green manuring crops after an application of rock phosphate. In this way the phosphorus of the rock may be made more quickly available for succeeding crops.

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APPLIED HYDROPONICS

From time to time the humus school point to Japanese farming as one of the models of natural economy—here, they argue, is a poor soil supporting an enormous population because human manures are returned to it. Indeed, so much is Japanese agricultural economy based upon human residues that a well-known writer about Japan, Mr. John Moore, in "Traveller to Tokio", has described how the municipal gentlemen in white gloves will knock at the door at most inconvenient moments to remove the food for Japan's future crops. We were not unpleased, therefore, to read an article by Mr. Ritchie Calder in the *News Chronicle* of 6th June, in which we learnt that the U.S. Army in Japan are setting up large "floating gardens" (hydroponic concrete basins) in order to keep the U.S. Forces supplied with fresh salad vegetables and fruits. To quote: "The reason is that Army health authorities will not allow troops to eat raw vegetables produced by Japanese cultivators from soil overworked with human germs of typhoid, para-typhoid, dysentery, and hookworm." This hydroponic development will be the biggest yet ventured upon. One water-farm will be 55 acres in size, another 25 acres. Cinder or gravel beds will be used on a percolation principle, and an ordinary farm fertilizer will form the basis of the nutrient supply. Nor is this project one that is concerning American alone, for Professor Tanaka, of Formosa University, and 50 graduates are voluntarily co-operating with Lt.-Col. Elliot, of the U.S. Eighth Army, in the work of setting up the soilless and fertilizer-fed farms; so that even the Japs seem to have some doubts about the efficiency of their traditional "organic farming". We congratulate the *News Chronicle* on publishing this new and significant information, and we cannot help wondering whether this newspaper has revised its opinions on the use of fertilizers—for we seem to remember other articles that we have liked much less, articles that have associated "chemical plant food" with soil deterioration and lower food values.

—Extract from *The Fertilizer Journal.*

BACTERIAL SOFT ROT OF VEGETABLES

By G. B. Wallace, B.Sc., Ph.D., Plant Pathologist, Department of Agriculture, Tanganyika Territory

(*Received for publication on 26th April, 1948*)

With the increasing cultivation of vegetables, disease problems are becoming more important. Soft rot, caused by *Bacterium carotovorum*, is one disease on which growers should have some information, as it can be destructive both in the field and in store. It has been seen in the Northern and Southern Highlands Provinces of Tanganyika Territory, in turnip (causing 20 per cent loss in one plot), carrot, cabbage, cauliflower, brussels sprouts, and celery. Other plants known to be susceptible are broccoli, potato, cucumber, onion, leek and other vegetables, tobacco and various flowering plants.

Infection starts from contaminated soil or diseased plants or trash, and usually enters through wounds or injuries caused by farm implements, insects and slugs, etc., but the bacteria can sometimes penetrate unbroken healthy tissues. The disease is most severe in warm moist weather, but in the case of celery it may appear even in dry weather. It is encouraged by heavy manuring and by frost damage, and it is said to be associated sometimes with boron deficiency in the soil.

Symptoms.—There are certain symptoms which characterize the disease in most of its host plants: the soft inner tissues, e.g. of stalks, roots and tubers disintegrate to a sodden, slimy and evil-smelling mess. The disease usually starts at wounds or injuries, and commonly at the base of leaves as in turnip, or in the stem as in cucumber—where it is known as "canker"; young plants of cucumber are sometimes attacked.

The following are further symptoms seen in particular plants. In cabbage and cauliflower the rot may spread from the stem into the head, and the latter may be partly hollowed and rotted before it eventually falls over; the curd may show brown patches, and in plants kept for seed these may not be formed. In broccoli the stem may be swollen. In turnip and carrot the root may be hollowed out until only an empty shell remains. Affected plants of onion and leek appear water-soaked or glassy before they completely break down; onions are more likely to be affected in store.

In potato the rot is seen when tubers are cut across. The inner tissues are soft, rotted and elastic or viscous; they are white or cream coloured with brown margins. The boundary of the rotted tissues and the sound firm tissues is sharply defined. As the rotted parts dry out they change from slimy to chalky. The stems may also be disintegrated. The disease in potato tubers may be confused with other diseases, and when it is suspected neighbouring vegetables should be examined.

The disease in tobacco is described in Rhodesia by J. C. F. Hopkins [2]. It is found there only in fields of heavy fire-cured tobacco. The bacteria enter the plant after topping, when water accumulates in the cut stalk. The pith is rotted away and has a strong smell, and eventually the stalk is hollowed out—the disease in tobacco is known as "Hollow stalk".

Control.—The following control measures are recommended to prevent the disease starting and to restrict its spread when it has started:—

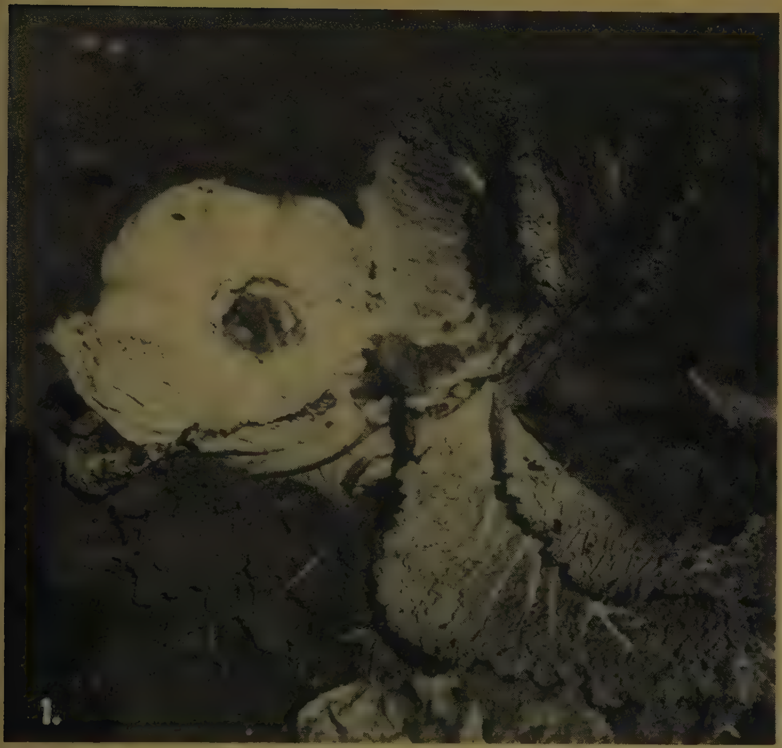
(1) Injuries by farm implements should be avoided as much as possible, and root crops should be lifted with care.

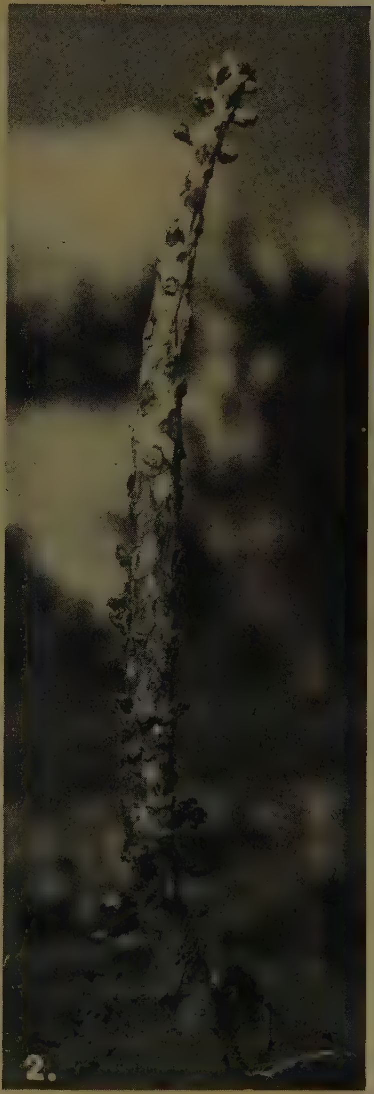
(2) Susceptible plants should be rotated with immune plants, and they should not be replanted on affected land for two years.

(3) In the field celery should not be earthed up above the hearts; cucumber is safer planted on mounds, and the stem bases should be kept dry; in the case of tobacco, topping should be done with a diagonal cut instead of horizontal to prevent water accumulating in the cavity. In Rhodesia it is stated also that in areas of high rainfall wounds made in topping may require to be treated with a disinfectant such as Carbolineum.

(4) Diseased plants in the field or in store should be removed and burned, and it may be advisable to remove and use at once the neighbouring plants. Affected plants should not be thrown on the manure heap or be put in compost.

(5) Early attacks in cucumber are said to be checked by dusting the bases of the plants with a copper-lime dust. Green [1] in England suggests rubbing the early affected parts with a powder made of three parts of flowers of sulphur, three parts of finely powdered copper





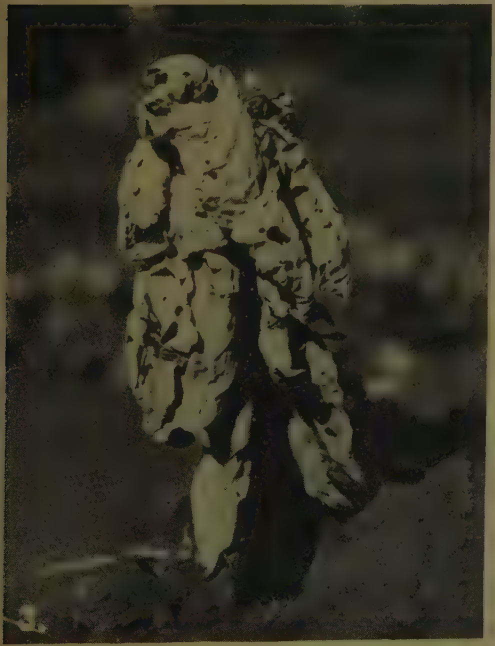


FIG. 1.—Cabbage infected with Bacterial Soft Rot. The head has fallen over, exposing the dark rot inside.

FIG. 2.—Brussels sprout plant attacked by Bacterial Soft Rot. Advanced stage, when all leaves and most of the sprouts have dropped off and the plant is rotten inside.

FIG. 3.—Brussels sprout plant which has begun to wilt as a result of Bacterial Soft Rot.

sulphate and ten parts of slaked (or hydrated) lime.

(6) Stores should be dry and airy, and only sound vegetables should be stored. Any injured roots, etc., should be used at once.

(7) Stores should be disinfected once a year with either a formalin solution (one pint in ten gallons of water) or with copper sulphate (1 lb. in ten gallons); the latter is less disagreeable to use.

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FERTILIZERS AND LEYS

We return, without apology, to the "meaty" 1945 *Journal of the Royal Agricultural Society*. Mr. B. H. Harvey, of the Essex Institute of Agriculture, discusses with considerable experience the establishment of leys in dry areas. With dry soils it is vital that good ground cover should be rapidly established, for bare patches lead to further drying and to weed competition. The best time for sowing seems somewhat undecided, but the Essex investigations point towards a practice of cross-drilling with a combine drill rather than to the broadcasting either of seed or fertilizer. "An interesting phenomenon that has been observed in cases of combine drilling is that the rows of seedlings braird in a much wider band. Whether this is due to the extra 'sputtering' of the seeds as they fall with the fertilizer remains to be investigated." In reporting that phosphatic fertilizers are of fundamental importance to ley establishment, Mr. Harvey points out that a relatively small application if combine-drilled will do as well as a larger application broadcast. Here we would comment that this indication is probably true of leys in all soils, whether dry or not, since it is yet another pointer to the efficiency of drilling and placing; and this leads to the need for "drillability" as a fertilizer property even where the crop is a ley.

—Extract from *The Fertilizer*, May, 1946.

A NOTE ON THE DETERIORATION OF THE TOXIC CONTENT OF SEPARATED PYRETHRUM ACHENES COMPARED WITH THAT OF WHOLE FLOWERS

By **J. Hopkins, Agricultural Chemist (Pyrethrum), Kenya**

(Received for publication on 14*th May,* 1948)

Considerable interest has been shown during the past year or so in the possibility of developing a more economical means of transport for pyrethrum by separating out the achenes from the rest of the flowerhead and baling these for export just as whole flowers are baled at the present time. It had long been known that the achenes contain approximately 90 per cent of the total pyrethrins present in the flowers (1). Thus, a very great saving in shipping space could be accomplished by exporting bales consisting of achenes only, the other parts of the flower being rejected or utilized for local products.

However, whereas the average loss in the pyrethrin content of whole-baled flowers had been established as 6.3 per cent in 95 days (2), the rate of depreciation of the pyrethrin content of separated achenes had not been investigated. An experiment was therefore designed to determine whether the rate of loss in toxicity in separted achenes varied from that in whole flowers, both being treated identically.

For this purpose, a quantity of material was supplied by Mr. E. W. Gaddum, the Agricultural Officer (Pyrethrum). This consisted of the product obtained by putting normally dried commercial pyrethrum flowers through a seed cleaning machine. The achenes thus obtained were not completely cleaned and still had the corollas attached; a few ray florets and scales were also present. As a control, a representative sample of the original whole flowers was also supplied.

Both the control and the achene materials were analysed immediately by the Wilcoxon-Holladay Mercury Reduction (A.O.A.C.) Method and by the Seil Acid Method.

Miniature bales were then prepared from representative samples obtained by quartering down the original material. A quantity of material contained in a cheese-cloth bag was placed in the basket of an oil press and sufficient pressure exerted to press the whole into a firm bale Each little bale thus produced was given an outer wrapping of heavy brown paper. One bale of whole flowers and three of achenes were made, all of about the same dimensions and weight. One of the bales of achenes was sprayed immediately after leaving the press with an aqueous solution of an antioxidant, sufficient spray being used to ensure adequate coverage of all surfaces. In the preparation of the fourth bale, the loose achenes

BALE REFERENCES No. I—Control—untreated whole Flowers.
II—Untreated Achenes.
III—Achenes, sprayed after baling with antioxidant.
IV—Achenes, sprayed with antioxidant before baling.

Bale No.		Original Py. Content			Py. Content after Storage			Actual Depreciation			Per cent of original Pys. lost			Per cent of original Pys. remaining		
		Py. I	Py. II	Total	Py. I	Py. II	Total	Py. I	Py. II	Total	Py. I	Py. II	Total	Py. I	Py. II	Total
(i) ANALYSED BY WILCOXON–HOLLADAY METHOD (A.O.A.C.)																
I	per cent	0·72	0·62	1·34	0·69	0·54	1·23	0·03	0·08	0·11	4·2	12·9	8·2	95·8	87·1	91·8
II	,,	1·07	0·83	1·90	0·92	0·72	1·64	0·15	0·11	0·26	14·0	13·2	13·7	86·0	86·8	86·3
III	,,	1·07	0·83	1·90	0·95	0·76	1·71	0·12	0·07	0·19	11·2	8·4	10·0	88·8	91·6	90·0
IV	,,	1·07	0·83	1·90	0·99	0·72	1·71	0·08	0·11	0·19	7·5	13·3	10·0	92·5	86·7	90·0
(ii) ANALYSED BY THE SEIL METHOD																
I	per cent	0·65	0·62	1·27	0·62	0·60	1·22	0·03	0·02	0·05	4·6	3·2	3·9	95·4	96·8	96·1
II	,,	0·94	0·84	1·78	0·85	0·78	1·63	0·09	0·06	0·15	9·6	7·1	8·4	90·4	92·9	91·6
III	,,	0·94	0·84	1·78	0·83	0·77	1·60	0·11	0·07	0·18	11·7	8·3	10·1	88·3	91·7	89·9
IV	,,	0·94	0·84	1·78	0·86	0·80	1·66	0·08	0·04	0·12	8·5	4·8	6·7	91·5	95·2	93·3

were sprayed with the antioxidant solution before being placed in the press.

All four bales were then stored together in a dark inner room, where a fairly constant temperature and humidity were maintained, and left undisturbed for 173 days*. Further analyses were then carried out, the results of which are reproduced in tabular form below. In order to simplify the tables only the figures representing the mean of several individual analyses on replicated samples have been shown.

In order to confirm the above results, Mr. V. A. Beckley, Scientific Adviser to the Pyrethrum Board, has carried out analyses by a spectrophotometric method which he has developed. Unfortunately, this method was not in operation when the analyses of the original material were made, but the figures obtained on the stored material are satisfactorily comparable with those of the chemical methods as shown in the following table:—

From the results of this experiment, it is evident that the rate of deterioration of the pyrethrum content of separated pyrethrum achenes is greater than that of whole flowers when both are baled and stored under identical conditions and that, although antioxidants can be used to retard this deterioration, achenes so treated will tend to deteriorate more rapidly than whole flowers.

Bale No.	Analysis by Chemical Methods		Analysis by Spectrophotometric Method	
	Total Pyrethrins		Total Pyrethrins	
	A.O.A.C.	SEIL	Hot Ext.	Cold Ext.
	per cent	per cent	per cent	per cent
I ..	1·23	1·22	1·24	1·06
II ..	1·64	1·63	1·61	1·38
III ..	1·71	1·60	1·61	1·44
IV ..	1·71	1·66	1·71	1·52

These preliminary results with miniature bales indicate the relative losses of pyrethrins that obtain. Further work is necessary to find out the relative losses on storage in commercial bales of whole pyrethrum flowers and achenes, and to study the practical possibility and the economy of baling pyrethrum achenes as opposed to whole flowers.

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*A mean maximum of 24.5° C with actual maximum of 27.8° and a mean minimum of 19.2° C with an actual minimum of 16.7° were recorded in the storage room during the period.

THE EFFECT OF SEED TREATMENTS, NURSERY TECHNIQUE AND STORAGE METHODS ON THE GERMINATION OF TUNG SEED

By C. C. Webster (Tung Experimental Station, Department of Agriculture, Nyasaland)

(*Received for publication on 11th May, 1948*)

INTRODUCTION

Tung trees of the species *Aleurites montana* are deciduous trees which in Nyasaland begin the season's growth at the commencement of the warm weather in September, flower and set fruit from the end of September to early November, and continue growth until the end of the rains in April or May, when the fruit falls and the leaves are shed. An indication of the climatic conditions in the main tung-growing area may be obtained from the figures for temperature and rainfall at the Tung Experimental Station shown in Table 1. The normal time for sowing seed in nurseries is in May and June, early in the cool, dry season. Such fresh seed usually gives a germination of from 75 to 90 per cent, but owing to the relatively low temperatures germination is slow and is not complete for at least 3½ months, while the growth of the young plants is also retarded by the cool, dry weather, in spite of the fact that the nurseries are watered once or twice daily from the time of sowing to the onset of the rains in November or December. As a result, seedlings have to remain in the nursery for 16 to 18 months before they are ready for budding, for although some of them may be big enough by February or March of the following year, there is no great advantage in budding then because they cannot be planted out as budded stumps until the rains begin in November or December. If the seeds are stored through the cold season, and then planted when the warm weather comes in September or October, germination is more rapid and the young seedlings grow more quickly, but unfortunately loss of viability occurs during storage and the percentage germination obtained is usually only from 30 to 50. If this loss of viability could be prevented it would be advantageous to delay sowing until September–October as the expense of watering over a long period would be saved and, owing to the more rapid germination and growth, the plants would still be ready to bud by October or November of the following year. Alternatively, the period in the nursery could be shortened if means could be found of accelerating germination and growth during the cold season so that the plants were big enough to bud by November or early December of the same year, but this would not eliminate the expense of watering. The preservation of viability during storage is, however, important from another point of view, as some planters find it desirable to plant out basket seedlings at the beginning of the rains for budding in the field in the following year, and to produce such plants of suitable size the seeds must not be sown until August as if they are sown earlier the plants are too big by the time the rains break.

The experiments herein recorded were therefore carried out during the period 1940 to 1945 with the object of finding means of accelerating germination and of preserving viability during storage. During the same period similar work was being done in America with the species *Aleurites fordii*, but much of this was not published until 1947 (2) (5). The similarity of the two species as regards germination is evident both from a comparison of some of the results obtained in America and Nyasaland and from the fact that some of the experiments reported below were repeated with *A. fordii* and gave the same results as with *A. montana*. Reference to American work is made at appropriate places below, but it should

TABLE 1

MEAN MONTHLY TEMPERATURES AND RAINFALL AT TUNG STATION (AVERAGE OF FIVE YEARS)

	Jan.	Feb.	Mar.	Apr.	May.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum temperature degrees F.	77·3	77·0	75·1	75·6	72·2	68·8	69·0	72·3	78·6	82·7	81·5	78·3
Minimum temperature degrees F. ..	63·1	63·0	62·0	59·5	55·7	52·0	51·5	52·2	55·1	61·7	63·7	62·7
Rainfall, inches ..	12·15	10·70	12·51	2·41	0·85	1·19	0·67	0·33	0·09	0·87	3·91	8·46

be borne in mind that their climatic conditions differ from those of Nyasaland and that much of their work has been on different lines.

METHODS

All the experiments were arranged in randomized blocks with from three to eight replications, factorial designs being employed with some of the later trials. Usually each plot contained 100 seeds, but in two trials there were only 50 seeds per plot and in several there were more than 100. Owing to the fact that there is variation in germination capacity between the seed from different parent trees, all plots contained equal numbers of seeds from the same parent tree or trees, except in one trial where two clones were compared. Care was also taken that that the seed was uniform in respect of time of harvesting and maturity. The seeds after removal from the fruits were sown outdoors in ordinary nursery beds made up as uniformly as possible as regards tilth, etc., and unless otherwise stated there was no shading or mulching. The seeds were sown with the long axis horizontal and the more convex side above, with one inch of soil above them, except in trials where other positions or depths are described. Spacing was four inches apart each way and was kept regular at planting time by using special wire frames. Watering was done uniformly over all plots. Emergence of the seedlings from the soil was regarded as germination and counts were made at intervals of from seven to ten days, the emerged seedlings being removed after each count to avoid shade and water consumption effects on the remaining seeds. In the tables below only the final percentage germination and the figure from one interim count are usually given, as obviously the presentation of data from all counts is unnecessary. As the figures from germination counts in such experiments form a series of discrete variates within the range 1 to 100, analyses of variance were made with transformed data as well as with the original values, the square root transformation being most commonly used. The results of such analyses, however, did not differ materially from those of the normal values and the latter are therefore presented here.

SEED TREATMENTS

The following seed treatments were tried in one or more experiments, being applied to the seed after its removal from the fruit:—

(1) Cleaning, or rubbing off the soft material which adheres to the outside of the shell.

(2) Soaking in cold water for 6, 24 or 48 hours.

(3) Soaking in hot water (maintained at 60 to 80°C.) for 24 or 48 hours.

(4) Grinding away a portion of the thickness of the shell near the hilum by holding the seed against a grindstone.

(5) Cracking the shell at the hilum end by tapping it with a knife.

(6) Exposure of seed to direct sunlight for periods of from 1 to 10 hours. This was done because it was observed that under certain conditions strong sunlight caused the shells to crack, thus providing, it was hoped, a simple way of imitating treatment 5.

Combinations of treatments 1 and 6 were also used. Most of the treatments were applied both to fresh seed sown in May or June and to seed which had been stored for several months and was then treated before sowing in September or October.

Effect of Cracking the Shell.—Cracking the shell of fresh seed invariably increased the speed of germination (*see* interim germination percentages in Tables 3, 4, 5, 6, and 7) and usually significantly improved the final percentage germination (Tables 4, 5, and 6). In one trial (Table 7) cracking significantly reduced the final percentage germination, but it is thought that this was because damage to the kernels resulted from the operation being done too fiercely and that no such reduction would be obtained if fresh seed were cracked carefully. With seed which had been stored for three to five months cracking neither accelerated germination nor improved the percentage which finally germinated (Tables 6 and 7, and also results of a third trial for which data is not presented). With seed of *A. fordii* in Mississippi, Merril [5] found that cracking the shells was definitely harmful, but he was evidently using seed which had been stored for several months. In Nyasaland cracking was effective in accelerating germination of fresh seed of *A. fordii* and usually gave a higher final germination.

Effect of Exposure to Sunlight.—Even with fresh seed exposure to sunlight could not be relied upon to bring about the desired effect of cracking the shells of the seeds. To achieve this it is evidently necessary to expose fresh seed with just the right moisture content to strong sunlight and this is not always possible. Only in one trial (Table 5) did cracking of shells occur as a result of exposure to the sun and then only 25 per cent of the seeds were cracked. In this experiment the treatment may possibly have had some beneficial effect on the speed and amount of germination, but the differences were not significant. In the other trials with fresh seed (Tables 3, 4, 6, and 7) it naturally had no effect on germination except in Experiment No. 4, where it probably reduced the final germination percentage. With stored seed exposure to sunlight, either with or without previous soaking in cold water, significantly reduced germination on all occasions (Tables 6 and 7).

Effect of Soaking in Water.—Soaking fresh seed in hot water for 24 hours significantly reduced both interim and final germination (Tables 2 and 4). Soaking in cold water for 6, 24 or 48 hours had no effect on the germination of either fresh or stored seed (Tables 2, 4, 6, and 7), except in Experiment No. 9 (Table 5) where it significantly reduced germination throughout. Merril [5] found that soaking whole fruits of *A. fordii* in water for 24 or 48 hours and then breaking them into one-seed pieces for planting was inferior to untreated controls in all respects.

Effect of Miscellaneous Seed Treatment.—Grinding away a part of the thickness of the shell near the hilum was only tried in one experiment in which it accelerated germination and gave a higher final germination as compared with the control (Table 2). Cleaning off the soft material adhering to the shell, and combinations of this treatment with exposure to sun, had no effect (Tables 2 and 4).

It will be seen that the only seed treatments which were effective in improving germination of fresh seed were cracking or grinding of the shell, and they were ineffective with stored seed. Both of these operations must be done carefully as the application of too much force is liable to spoil the kernel or embryo and to reduce the number of seeds which germinate. Neither method is very suitable for practical application on a large scale as no method of effecting the treatments mechanically has been devised locally.

TABLE 2

EXPERIMENT 2(*c*), SEEDS SOWN 4–5–1940

PERCENTAGE GERMINATION

Days after sowing	75	120
Control, untreated	46	69
Cleaned, by removing soft material	44	76
Soaking 24 hours in cold water	46	64
Soaking 24 hours in hot water	26	40
Ground	68	87
Significant difference, P=0·05	12·5	13·7
Significant difference, P=0·01	20·8	22·7

TABLE 3

EXPERIMENT 4, SEEDS SOWN 4–6–1940

PERCENTAGE GERMINATION

Days after sowing	60	100
Control, untreated	9·3	83·4
Cracked	53·3	92·0
Exposed 1 hour to sun	9·3	74·6
Exposed 10 hours to sun	18·0	64·0
Significant difference, P=0·5	16·0	15·4
Significant difference, P=0·01	24·3	23·4

TABLE 4

EXPERIMENT NO. 5, SEEDS SOWN 4–6–1940

PERCENTAGE GERMINATION

Days after sowing	60	90
Control, untreated	54·7	74·7
Cracked	92·0	92·0
Exposed to sun 10 hours	64·7	79·3
Cleaned	52·0	75·3
Cleaned and exposed to sun 1 hour	58·7	82·0
Cleaned and exposed to sun 10 hours	42·0	76·7
Soaked 24 hours in cold water	68·7	80·7
Soaked 24 hours in hot water	36·7	46·7
Significant difference, P=0·05	17·7	11·3
Significant difference, P=0·01	24·6	15·7

TABLE 5

EXPERIMENT NO. 9, SEEDS SOWN 10–5–1941

Days after sowing	60	130
Control, untreated	58·0	73·6
Cracked	94·8	97·6
Soaked 48 hours in cold water	23·2	30·8
Exposed to sun for 2 hours	70·8	88·0
Exposed to sun for 10 hours	70·8	86·8
Significant difference, P=0·05	18·6	15·0
Significant difference, P=0·01	25·6	20·7

TABLE 6

EXPERIMENT NO. 14, SEEDS SOWN 5–6–1942 (FRESH SEED) AND 8–9–1942 (STORED SEED)

PERCENTAGE GERMINATION

	Fresh seed		Stored seed	
Days after sowing	70	150	70	110
Control, untreated	6·2	55·2	39·4	40·8
Cracked	62·0	75·4	35·4	35·6
Exposed to sun 10 hours	6·8	58·8	27·2	28·0
Soaked 48 hours in cold water	5·6	50·2	35·8	36·2
Significant difference, P=0·05	6·8	9·1	6·8	9·1
Significant difference, P=0·01	9·2	12·3	9·2	12·3

TABLE 7

EXPERIMENT NO. 22, SEEDS SOWN 29–5–1944 (FRESH SEED) and 31–10–1944 (STORED SEED) PERCENTAGE GERMINATION

	Fresh seed		Stored seed	
Days after sowing ..	70	150	70	100
Control, untreated ..	52·0	79·1	43·6	46·9
Soaked 6 hours in cold water	50·5	72·1	43·5	45·0
Soaked 6 hours in cold water and exposed to sun 6 hours ..	57·5	76·5	23·4	26·0
Cracked	61·3	65·2	23·2	25·0
Significant difference, P=0·05	7·7	8·0	7·7	8·0
Significant difference, P=0·01	10·1	10·6	10·1	10·6

NURSERY TECHNIQUE

Media.—Using seed of *A. fordii* under greenhouse conditions, Shear and Crane [6] found that Sphagnum moss, fresh sawdust and sand were excellent media in which to germinate tung seed. In Nyasaland, however, in experiments conducted out of doors during the cool season, it was found that ordinary soil (a medium red loam) was much superior to coarse river sand or *Eucalyptus* sawdust, both of which gave relatively poor germination (Table 8).

Position of Seed when Sown.—An experiment was carried out to see if the position of the seed when sown would have any effect on germination or on the development of the main root of the seedling as it was observed that seedlings were occasionally found with markedly twisted roots. Seeds were sown in the following positions:—

(*a*) Long axis horizontal, most convex side of seed uppermost, hilum at side.

(*b*) Long axis horizontal, least convex side of seed uppermost, hilum at side.

(*c*) Long axis vertical, hilum at top.

(*d*) Long axis vertical, hilum at bottom.

In view of the normal method of emergence of the young seedling from the seed, it appeared that positions (*a*) and (*b*) were likely to be most suitable. The results (Table 9) showed that position (*d*) significantly reduced germination, but there was no difference between any of the other three positions and no twisted roots were developed by any treatment.

Shade.—During the cool season a moderate shade made of grass and placed three feet above the beds so that direct sunlight only fell on the soil in the early morning and late afternoon resulted in no emergence of seedlings during the first 50 days after sowing, although emergence proceeded normally on unshaded beds (Table 10). The shades were removed 50 days after sowing, whereupon germination proceeded, the final percentage being higher on the initially shaded beds than on the unshaded, but not significantly so.

TABLE 8

EXPERIMENT NOS. 1 (*b*) AND 2 (*b*) SEEDS SOWN 30–4–1940 AND 4–5–1940. PERCENTAGE GERMINATION

Days after sowing	Soil	Sand	Sawdust	Significant difference	
				P=0·05	P=0·01
1(*b*) 75 ..	51·0	41·2	9·6	12·4	16·8
1(*b*) 120 ..	76·6	57·0	22·0	10·0	13·6
2(*b*) 75 ..	46·0	24·8	2·8	10·8	15·6
2(*b*) 120 ..	67·2	41·8	13·6	15·4	22·1

TABLE 9

EXPERIMENT NO. 6, SEEDS SOWN 20–6–1940 PERCENTAGE GERMINATION

Days after sowing	65	90
Long axis horizontal, convex side up ..	35·0	73·0
Long axis horizontal, convex side down	34·2	70·7
Long axis vertical, hilum up ..	39·2	76·0
Long axis vertical, hilum down ..	10·0	43·1
Significant difference, P=0·05	10·0	8·2
Significant difference, P=0·01	13·6	11·2

TABLE 10

EXPERIMENTS NOS. 1(*a*) AND 2(*a*), SEEDS SOWN 30–4–1940 AND 4–5–1940. PERCENTAGE GERMINATION

Days after sowing	Experiment No. 1(*a*)			Experiment No. 2(*a*)		
	*Shade	No shade	Significant difference P=0·05	*Shade	No shade	Significant difference P=0·05
50	0·0	42·0	—	0·0	25·2	—
75	35·6	66·4	10·2	40·0	52·0	11·2
120	82·4	70·8	14·2	71·6	62·8	11·8

*Shade removed 50 days after sowing.

Mulching, Depth of Sowing and Watering.—A factorial experiment was carried out in 1943 in which all combinations of the treatments given below were applied (*a*) to fresh seed sown soon after harvest on 6th June and (*b*) to seed stored in a cool, dry store and planted on 11th September, the seed for both times of planting being harvested from the same parent trees at the same time. The treatments were as follows:—

(1) Depth of planting: (*a*) Shallow, 1 in. of soil above seed; (*b*) deep, 2 in. of soil above seed.

(2) Watering: (*a*) Watering on alternate days only; (*b*) daily watering.

(3) Mulch: (*a*) No mulch; (*b*) beds mulched with a layer of fine grass.

The same amount of water (two gallons per square yard) was applied at each watering, so that plots watered daily received twice as much water as those watered only on alternate days. Data from interim and final germination counts in both seasons are shown in Table 11. The 1 in. planting depth gave more rapid and better germination than the deeper planting in the cold season, but the depth of planting made no difference in the hot season. Mulching the beds very considerably reduced the percentage of seeds which germinated in either season, but it must be mentioned that many of the seeds under the mulch which did not germinate during the experiment remained viable and germinated later when the mulch was removed. On the unmulched plots watering on alternate days was better than daily watering during the cold season, but the reverse was true in the hot season. This is probably because in the cold season watering on alternate days provides adequate moisture and daily watering exercises an adverse effect by lowering the soil temperature, whereas early in the hot season, when evaporation is obviously greater, daily watering is necessary to maintain sufficient moisture in the surface soil. Later in the hot season there is naturally no difference between watering treatments as the rainy season begins. Similar results as regards the watering on unmulched beds had been obtained from Experiments Nos. 16 and 17 in the previous year (Table 12). In Experiment No. 16 a comparison was also made between plots in which the surface soil was made firm by gentle pressure before sowing and others in which it was left loose, but these treatments had no differential effect on germination.

TABLE 11

Experiment Nos. 18 and 19, Seeds Sown 4–6–1943 and 11–9–1943. Percentage Germination

	Cold Season		Hot Season	
Days after sowing	70	140	70	100
Shallow (1in. of soil above seed)	9·1	48·9	29·4	42·3
Deep (2in. of soil above seed)..	5·1	39·9	32·2	42·1
No mulch	13·5	74·2	48·5	55·4
Mulch	1·0	14·6	13·1	29·0
Significant difference, P=0·05	2·6	5·2	4·5	5·2
Significant difference, P=0·01	3·6	6·9	6·1	6·9
No mulch, watered alternate days	17·9	85·4	42·4	50·9
No mulch, watered daily	9·1	63·1	54·6	59·9
Mulch, watered alternate days	1·0	15·7	15·0	32·1
Mulch, watered daily	1·0	13·5	11·1	25·9
Significant difference, P=0·05	3·7	7·3	6·4	7·3
Significant difference, P=0·01	5·0	9·8	8·7	9·8

TABLE 12

Experiments Nos. 16 and 17, Seeds Sown 15–6–1942 and 11–9–1942. Percentage Germination

	No. 16, Cold Season			No. 17, Hot Season	
Days after sowing	75	120	150*	75	120
Watered alternate days	22·7	65·9	68·4	32·4	34·2
Daily watering	9·7	54·3	61·2	39·2	41·2
Surface soil firm	16·3	62·4	67·2	..	..
Surface soil loose	16·0	57·8	62·2	..	..
Significant difference, P=0·05	6·7	11·1	10·8	5·8	5·6
Significant difference, P=0·01	9·0	—	—	8·0	7·8

*Rain fell just before this count.

Early Harvesting and Sowing of Seed.—A trial was made to find out if it would be possible to harvest and sow seeds in March and April and, as a result of this early sowing, to produce plants big enough to bud by the following budding season, i.e. October to December of the same year. If successful this would shorten the time in the nursery by nearly a year, but it was not known whether seeds harvested and sown so early would germinate. Seed was collected from three adjacent budded trees of clone No. 14, which is a clone which matures its fruit earlier in the season than most others. Dates of harvesting and sowing were as follows:—

(1) Harvested 2nd March, sown 3rd March. No fruit had begun to fall from the trees at this date and the seed was all obtained from green fruits picked off the trees. Seeds appeared to be completely filled and had well-developed cotyledons and embryo.

(2) Harvested and sown 14th March. Fruit was just beginning to fall, but 90 per cent of the seed came from green fruit picked off the trees.

(3) Harvested and sown 2nd April. Fifty per cent of the seed was from fallen fruit and 50 per cent from fruit on the tree which was fairly ripe and yellow.

(4) Harvested and sown 1st April. Seventy per cent of seed was from fallen fruit and 30 per cent from ripe fruit on tree.

(5) Harvested and sown 1st May. All the fruit had fallen from the trees by this date and all was collected.

(6) Sown 15th May. This seed was taken from fruit collected on 1st May which had been kept in the store since that date.

There were three plots of 100 seeds each for each sowing date, and as they emerged in the seed beds, the seeds were removed and replanted in other beds at a spacing of 2½ ft. x 1½ ft. until 150 seeds from each treatment had been so transplanted. This formed another trial of three randomized blocks each containing one plot of 50 seedlings from each sowing time, and this trial was used to compare the growth of the seedlings. The results are summarized in Table 13. The highest percentage germination was given by the seeds sown in April, but even the earliest treatment gave a germination of over 80 per cent. The speed of germination of seeds sown in March, especially of those sown on 3rd March, was slower than that of the April sowings which reduced the advantage of the March sowings as regards growth. The May sowings gave a lower final germination and a slower speed of germination than all others. None of the plants were anything like big enough to bud by the following December, in fact they were still so small that girth measurements were difficult and only the heights were recorded.

A similar experiment was conducted in the following season, but in this trial two clones were used, No. 14 which matures its crop early in the season and No. N24 which ripens the fruit later than the majority of clones. A further treatment was introduced by cracking half the seeds in the manner previously described. Sowing dates were as follows:—

(1) Harvested 1st March, sown 2nd March. All seeds were from fruit picked off the trees; fruit of clone 14 was ripening and changing colour, that of N24 was still very green.

(2) Harvested 31st March, planted 1st April. Almost all the seed of clone 14 came from fallen fruit, but no fruit of N24 had yet fallen and green fruits were picked from the trees.

(3) Sown 1st May. Seed of clone 14 was from fruit which had fallen and been collected three weeks previously; 90 per cent of the N24 seed was from fruit which had fallen during the previous week and the remainder from ripe fruit picked off the tree.

Final germination percentages are summarized in Table 14. With clone 14 excellent germination was obtained from the first two sowing dates, but that from the May sowing was significantly less. This clone evidently matured its crop rather earlier than in the previous season and the speed of germination was greatest from the March sowing. With the later maturing clone N24 germination was much better when sown in May than in March. The untreated April sowing of this clone gave an exceptionally low germination which cannot be explained and is probably unreliable. Speed of germination of untreated seed of both clones (as seen from graphs prepared from the weekly counts) was most rapid in March, slower in April and still slower in May, but this is due mainly to the warmer and wetter conditions in March and April. (Rainfall was 20 inches in March and 2.07 inches in April.) There is a fairly strong indication from these results and from those of Experiment No. 25, that the highest final germination will be obtained by sowing seed from fruit which is just fully ripe. Cracking the seed of either clone in March had no effect on final germination and little on speed of germination. Cracking presumably accelerates germination by facilitating the intake of water and it is probable that with fresh seed, moist soil and relatively high temperature, water uptake is adequate in untreated seed. Cracking in April or May greatly accelerated germination (*see*, for example, Table 15) and with clone 14 gave a significantly higher final germination from the May sowing. The validity of the apparent increase in final germination due to cracking N24 in April is doubtful. Once again none of the plants were big enough to bud by the following December.

It is possible that if the seeds of clones which ripen their fruit early were sown in February, and if the slight check which occurs when the germination seeds are transplanted was eliminated, then plants big enough to bud might be produced by the end of the year. It is not, however, very probable, as the plants in these trials were very much smaller than the required size by December in each season. Further investigation has not been made as the results from experiments on the stratification of seed (given below) provide a simpler solution to the problem of reducing the time in the nursery.

TABLE 13

EXPERIMENT NO. 25, 1945. FINAL PERCENTAGE GERMINATION, AND HEIGHT DECEMBER, 1945

Date Sown	Germination per cent		Height, inches	
		Monthly means		Monthly means
3rd March	81·3	—	15·2	—
14th March	80·7	81·0	21·2	18·2
2nd April	91·7	—	16·6	—
14th April	94·7	93·2	12·0	14·3
1st May	70·3	—	11·1	—
15th May	66·7	68·5	7·5	9·3
Significant difference, P=0·05	12·0	8·5	5·3	3·8
Significant difference, P=0·01	17·1	12·1	7·6	5·4

TABLE 14

EXPERIMENT NO. 27. PERCENTAGE GERMINATION

Treatment	Sowing date			Significant difference	
	2nd March	1st April	1st May	P=0·05	P=0·01
Clone 14, untreated	97·0	91·0	78·0	9·3	12·6
Clone 14, cracked	94·7	97·3	94·0	9·3	12·6
Clone N24, untreated	63·3	39·3	81·7	9·3	12·6
Clone N24, cracked	69·7	84·7	87·3	9·3	12·6
Clone 14, both seed treatments	95·8	94·2	86·0	6·6	8·9
Clone N24, both seed treatments	66·5	62·0	84·5	—	—

TABLE 15

EXPERIMENT NO. 27, CLONE 14, SOWN 1ST APRIL. PERCENTAGE GERMINATION AT VARIOUS DATES

Date	27/4	18/5	15/6	13/7	27/7	31/8
Untreated	4·6	17·3	53·0	62·3	65·3	75·0
Cracked	71·0	96·0	96·3	97·3	97·3	97·3

STORAGE METHODS

In 1943 an experiment was conducted in which both hulled seed and fruit sections were stored for four months before sowing in the following ways:—

(1) Normal storage, in small bags in a cool, dry store.

(2) Mixed with dry, powdered charcoal and stored in tins.

(3) Dried thoroughly in the sun and then stored as (1).

(4) Stored in small pits by a method which Leach [3] found advantageous with tea seed. Pits were dug in the ground, 15 inches deep by 18 inches by 12 inches, filled with seed or fruit sections and covered on top with a layer of dry grass thatch. This grass was removed daily, watered, surplus water shaken off and the grass then replaced over the pits. The whole set of six pits were sheltered by a thatched roof four feet above ground level. After four months' storage by this method the seeds were obviously moister than those from the other treatments.

The results are shown in Table 16, from which it will be seen that none of the treatments was successful in improving germination as compared with the low figure given by the normally stored seed which had obviously lost viability considerably during storage. The seeds which were sun-dried and both seeds and fruit sections which were stored in pits all gave significantly poorer germination than that obtained after normal storage. The same results were obtained from a similar experiment carried out in the following season.

Stratification.—With seed of *Aleurites fordii* good results have been obtained by stratification. Sharpe and Merril [7] found that stratification in clean sand under cool, moist, but well-drained, conditions definitely hastened and improved germination, although stratification of the whole fruit was not so successful. Lai Yung Li [4] stratified seed in sphagnum moss moistened with water for four months and obtained similar results, stratified seeds beginning to emerge four weeks after sowing and giving 80 to 90 per cent germination after eight weeks, while control seeds did not begin to emerge until five to seven weeks after sowing, took 11–15 weeks to complete emergence and gave a lower final percentage germination.

Experiments in Nyasaland have shown that stratification is similarly beneficial with seeds of *A. montana*. In the first trial, made in 1944, seeds were (*a*) stratified in moist sand, (*b*) stratified in moist sawdust, and (*c*) stored in a normal manner in cloth bags in a cool, dry room. Stratification was carried out in four-gallon petrol tins, layers of seed one seed thick alternating with two-inch layers of sand or sawdust. Slits were cut in the sides and bottoms of the tins to allow circulation of air, the tins were kept in a cool store and water was occasionally sprayed on to the surface of the sand or sawdust if it became dry. Final germination percentages are shown in Table 17 from which it will be seen that there were no difference between the two stratification treatments, but both gave significantly better germination than the normally stored seed. Stratification also greatly accelerated germination. Stratified seeds began to emerge 14 days after planting and 70 per cent had come up after 40 days, but the control seeds did not begin to emerge until 37 days after planting and only 9 per cent were up after 40 days. It would be simpler if the seeds could merely be mixed with moist sand instead of being carefully arranged in layers. A second experiment was therefore made in which seeds were (*a*) stored normally, (*b*) stratified with layers of moist sand, and (*c*) merely mixed with moist sand, the same number of seeds being put in the same sized container with the same amount of sand as in (*b*). In this trial wooden boxes measuring 14 x 10 x 21 inches were used as containers and holes were drilled in the sides and bottoms. The seeds were stored for five months and the results (Table 18) showed that there was no difference between the two methods of stratification, but that both were superior to normal storage.

TABLE 16

EXPERIMENT NO. 15, SEEDS SOWN 17–9–1943. FINAL PERCENTAGE GERMINATION

Storage method	Seed	Fruit Sections	Mean
Normal	45·4	41·4	43·4
Stored mixed with charcoal	44·2	39·0	41·6
Sun dried before storage	35·2	41·6	38·4
Stored in pit	25·0	22·0	23·5
Significant difference, P=0·05	5·1		3·6
Significant difference, P=0·01	6·9		4·4
Mean of all storage treatments	37·5	36·1	—

In a third trial seeds were again stratified between layers of moist sand in wooden boxes and were held in storage for three different periods, viz., approximately 4½, 5½ and 6½ months. (All seeds were stratified on 5th May, 1945, and the different batches were removed and sown on the following dates: 24th September, 1945, 20th October, 1945, and 18th November, 1945.) Seeds sown after 4½ months took rather longer to begin emergence than the other two treatments, but thereafter the speed of germination was the same for all three treatments and there was no significant difference between the final germination figures (Table 19). As they emerged in the seed beds the seedlings were transplanted to other beds at a spacing of 2 ft. x 1½ ft. and arranged in another randomized block trial for comparison of their subsequent growth. By the end of October of the following year all were big enough to bud and a comparison of mean figures for girth at three inches above ground level (Table 19) showed no significant differences between treatments. Stratification was carried out on a larger (non-experimental) scale in 1947 when 80,000 seeds were mixed with moist sand and stored in boxes from April to October. On planting they gave a final germination of just over 90 per cent.

These experiments therefore show that seeds may be stored by the stratification method from just after harvest in April or May right through the cool season until October without appreciable loss of viability. When sown in the warm weather of October they germinate rapidly and will produce plants big enough to bud by a year later. The period in the nursery is thus shortened by five or six months and most of the labour and expense of watering is saved since seeds sown in October only need watering for one month as against six or seven months for those sown in April or May.

Merril [5], working with seeds of *A. fordii*, has indicated that the beneficial effect of stratification is due to absorption of water by the seeds during storage under this method accompanied by enzymatic and other physiological charges which prepare the seed for germination as soon as temperature and other conditions permit.

TABLE 17

EXPERIMENT NO. 23, STORED 20–6–1944, PLANTED 4–10–1944. FINAL PERCENTAGE GERMINATION

Storage method	Germination per cent	Significant difference	
		P=0·05	P=0·01
Normal storage	52·5	—	—
Stratified in sand	80·8	10·8	16·9
Stratified in sawdust	80·0	—	—

TABLE 18

EXPERIMENT NO. 28, STORED 3–5–1945, PLANTED 3–10–1945. FINAL PERCENTAGE GERMINATION

Storage method	Germination per cent	Significant difference	
		P=0·05	P=0·01
Normal storage	28·2	—	—
Stratified between layers of sand	64·5	11·1	16·8
Mixed with sand	62·8	—	—

TABLE 19

EXPERIMENT NO. 26, STORED 5–5–1945

Storage time	Final Germination per cent	Girth inches 31–10–46
Stratified for 4½ months	82·7	3·1
Stratified for 5½ months	88·6	2·7
Stratified for 6½ months	81·5	2·6

TABLE 20

Moisture content of seeds, per cent	0·70	3·40	4·50	4·96	6·42	7·28
Germination, per cent	8·7	58·7	53·3	48·9	39·1	2·2

Effect of Moisture Content of Seeds during Storage.—Brief reference may be made to an experiment which was carried out with the help of Mr. E. O. Pearson, of the Empire Cotton Growing Corporation, who had at his disposal a constant temperature room. Seeds were conditioned to various moisture contents by being kept at a constant temperature of 30° C. in sealed jars over solutions of sulphuric acid giving relative humidities ranging from 2 to 70 per cent, according to a method described by Buxton and Mellanby [1]. The seeds were weighed at weekly intervals until no further change in weight occurred and then removed and stored in sealed tins at the same temperature of 30° C. for a period of twenty weeks, after which they were immediately planted in germination test beds. Duplicate samples were taken at the same time for determination of moisture content. The mean values for moisture content and final germination percentage for the six treatments are shown in Table 20. There is an indication that when tung seed is stored at the rather high temperature of 30° C. its viability declines as the moisture content of the seeds increases above about 3 per cent. A sample of the same seed which had been conditioned to 10.58 per cent moisture content—higher than any of the seeds in Table 20—was kept in cold storage at a temperature of 1 to 3° C. and this gave a final germination percentage of 46.7 per cent.

Large *et al.* [2] have found that seed of *Aleurites fordii* showed a much slower decline in viability when kept in cold storage at 34–36° F. than when stored at appreciably higher temperatures. They also noted that tung seed stored at ordinary temperatures at Bogalusa, Louisiana, declined in viability more rapidly than similar seed stored at Belstville, Maryland, and suggested this was because of the warmer and more humid climate of Louisiana. They indicate that there may well be a parallel between storage of tung seed and cotton seed, and quote Simpson [8] who reported that viability of cotton seed declined most rapidly when held at high temperatures and in air that was high in humidity. The small experiment described in the previous paragraph provides some evidence in support of these views. Further storage experiments with both temperature and humidity controlled at various levels would no doubt provide a complete picture of the effect of these factors on viability but facilities for such work are not available in Nyasaland.

SUMMARY

Seasonal climatic conditions in relation to tung nursery work in Nyasaland are described and an account is given of experiments which aimed at reducing the time required to produce plants big enough to bud, and at minimizing watering costs, by accelerating the rate of germination of the seeds or by eliminating the loss of viability which normally occurs during storage of seeds.

Seed treatments which were tried included: cleaning off soft material adhering to the shell; soaking in hot or cold water; grinding away part of the shell at the hilum end; cracking the shell either mechanically or by exposure to strong sunlight, the latter method, however, proving unreliable as a means of causing cracking. None of these treatments were effective in improving the germination of seed which had been stored for several months but grinding or cracking accelerated speed of germination and usually improved final germination of fresh seed. Neither method is very suitable for practical application on estates as no means of effecting the treatments mechanically without damaging a proportion of the seeds has been devised.

Experiments on nursery technique showed that shading or mulching the nursery beds is undesirable and that the position in which the seed is placed is immaterial unless the hilum end is pointing downwards, in which case the speed of germination and final percentage emergence is reduced. Sowing with 1-inch depth of soil above the seed was better than with 2 inches depth. In the cool season watering on alternate days at the rate of 2 gallons per square yard was superior to daily watering at the same rate but in the hot season the reverse was true. With a clone which matures its crop early, seeds taken from green fruit picked off the tree at the beginning of March and sown immediately gave a good germination but despite the early sowing the resulting plants were not big enough to bud by the end of the same year. On the other hand, with a clone which ripens its crop rather later, appreciably better germination was obtained from seed collected and sown at the beginning of May than from that sown two months earlier, indicating that the best germination is obtained if the seed is collected and sown when the fruits are just fully ripe.

Several methods of storage were tried but the only one which prevented loss of viability was by stratification in moist sand or sawdust.

Seed which is merely mixed with moist sand and stored in boxes in a cool building will preserve its viability for periods of up to six and a half months and on planting will germinate very rapidly. Plants raised from such seed are ready for budding one year later and storage by this method therefore enables the time in the nursery to be shortened by five to six months and eliminates most of the expense of watering necessary throughout the dry season.

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TROPICAL GRAPES

In the past grape cultivation has not been a success in damp, tropical regions for the reason that the varieties tried came from temperate climates. Breeding work is in progress at Turrialba which is aimed at breeding distinct new types of tropical vines, developed for the most part from wild tropical and subtropical American grapes. The tropical species most used in the breeding programme have been *Vitis shuttleworthii*, *V. tiliæfolia* and *V. gigas*. Certain selections show great promise for tropical regions, being equal to many of the better North American cultivated varieties in yield, quality and appearance and size.

—The Inter-American Institute of Agricultural Sciences Annual Reports for the years 1944–45 and 1945–46, pp. 36 and 68.

REPORT ON A TRIAL WITH D.D.T. AND B.H.C. FOR THE PROTECTION OF TIMBER AGAINST TERMITES

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SUMMARY

A trial was carried out over a period of seventeen months in termite infested land at the Agricultural Research Station, Kawanda. A susceptible local timber was completely protected by all of ten formulations of D.D.T. and B.H.C., while out of eight untreated slabs six were more than half eaten, and only one remained undamaged. Boundary posts treated with creosote were also damaged.

MATERIAL

Eighty-eight slabs of one inch planking, six inches wide and from six to eight inches long were used in the trial. The timber, "musizi", *Mæsopsis eminii* is described by Eggeling (1940) as fairly soft but firm, medium and even in texture, not resistant to termites, but responds well to preservative treatment. Sawn eucalyptus boards were used to test the chosen area before the experiment, and at intervals during its course. Eucalyptus poles were used to demarcate the two plots until destroyed by termites, when they were replaced by posts of sown "mpewere", *Piptadenia africana,* which had received the customary brushing with creosote.

TREATMENT

The treatment of the test slabs was carried out by Mr. C. B. Symes of the Colonial Insecticide Research Organization, to whom I am indebted for this assistance. Ten formulations were used, as detailed below, four slabs were dipped in each one for a few seconds and another four soaked for thirty minutes, making 20 treatments. Eight slabs were untreated.

(1) D.D.T. 5 per cent; solution in Dieseline.

(2) D.D.T. 5 per cent; solution in equal parts of power kerosene and cotton seed oil.

(3) D.D.T. 5 per cent; T.P. 520, proprietary emulsion.

(4) D.D.T. 5 per cent; T.P. 521, proprietary soluble oil.

(5) D.D.T. 5 per cent; A. 19.

(6) D.D.T. 5 per cent; A.T.S.O., proprietary emulsion

(7) B.H.C. 5 per cent; D. 929, crude Gammexane concentrate, solution in equal parts of kerosene and cotton seed oil.

(8) B.H.C. 5 per cent; D. 929, solution in Dieseline.

(9) B.H.C. 1 per cent; M.G. 035, Gammexane miscible oil.

(10) B.H.C. 1 per cent; L.G. 037, Gammexane liquid concentrate.

LAYOUT

The 88 slabs were divided into two equal groups, odd numbers and even. Each group was randomized and set out in regular rows to form two "graveyards" each approximately five feet square. The slabs were buried so that some two inches was left exposed. Graveyard A (even numbers) was arranged beside a low mound of *Pseudacanthotermes spiniger*, while B (odd numbers) was set out ten yards away over an area where a small—one foot—mound of *Bellicositermes natalensis* had been levelled off. Each graveyard was fenced off with corner posts and barbed wire. In view of the uniformity in the protection given by all treatments, only the untreated slabs are numbered on the following layout plans.

A

x	x	x	x				
x	x	x	x	x	x	x	x
88	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x
x	86	x	84	x	x	82	x

B

x	x	x	x	83	x	85	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x
87	x	x	x	x	x	x	x	x	x	81
x	x	x	x	x	x	x	x	x	x	x

RESULTS

The graveyards were laid down on 17th August, 1946, after a preliminary test with eucalyptus had shown termites to be active on the site. Test A was alongside an active mound of *P. spiniger*, then irregularly oval in shape, some 30 inches on the long axis and 14 inches high. *P. spiniger* is not one of the major pests of timber, but is an active collector of cellulose from dried twigs, mulch and the like. Test B was placed over the site of a small mound of *B. natalensis*, one of the major pests of timber. Four eucalyptus poles marked the corners of each plot.

The first examination was made after four months, on 21st December, 1946. In A, it was found that the mound had grown over some of the slabs in the first two rows. In B, no attempt had been made to replace the original mound and there were no surface workings of *B. natalensis* to be seen either on the slabs or on the ground between. No treated slabs in either plot showed signs of termite damage. Of the untreated slabs Nos. 82, 88 and 85 were slightly damaged by a small termite *Microtermes* sp. not yet determined specifically (Harris, 1948, "No. 490") but representative of a group which probably does more damage to timber on or in the ground than any other in East Africa. (Harris, 1943.) The eucalyptus poles were all showing damage by *B. natalensis*.

On 3rd February, 1947, after six months the poles had all been eaten away below ground and were replaced by "mpewere" posts. Some extra slabs of eucalyptus were buried in plot A on the opposite side of the termite mound to the graveyard.

On 30th January, 1948, after 17 months the following results were obtained:—

(i) Treated slabs—all intact; the only signs of possible termite damage were slight marks on two adjacent slabs from the middle of B which might represent tentative approaches by *Bellicositermes*.

(ii) Untreated slabs—only one was virtually undamaged, the details being—

(81) much damage below ground, apparently by *Microtermes;*

(82) much damage below ground, apparently by *Microtermes;*

(83) much damage below ground, apparently by *Microtermes;*

(84) only superficial damage, *B. natalensis* type.

(85) almost all eaten away, apparently by *B. natalensis;*

(86) almost all eaten away, apparently by *B. natalensis;*

(87) virtually undamaged.

(88) almost all eaten away by *B. natalensis*.

(iii) Untreated eucalyptus slabs in A—portions of three were recovered, two of which were being actively attacked by *Microtermes*, the third a small relic of *Bellicositermes* or other large species attack.

(iv) Fence posts—all four around A were undamaged; of the four around B, three showed considerable damage by *Bellicositermes* and the fourth was slightly damaged.

CONCLUSIONS

A concentration of timber impregnated with D.D.T. and benzene hexachloride was repellent to *Bellicositermes natalensis*, but not to *Pseudacanthotermes spiniger*.

Small slabs of susceptible timber were protected for 17 months by dipping for a few seconds in 5 per cent D.D.T., made up as solution or emulsion in six separate formulations. Similar protection was given by B.H.C. as a 5 per cent solution in oils, and as a 1 per cent aqueous dilution of a Gammexane miscible oil and a similar liquid concentrate.

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NOTE ON A METHOD OF PRESERVING SEPARATED MILK AS CHEESE

By **M. A. Barrett, B.Sc. Dairying (Reading), N.D.D., Agricultural Officer, Kenya**

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The ideal method of preserving the food value of separated milk is by spray drying to a powder, but this method necessitates a considerable daily gallonage of milk, although a roller drier may be operated economically on 500 gallons per day. In Kenya where the gallons per acre per year are low the difficulty would be to collect enough skim milk to supply a drying plant.

The following method may have its application to conditions in East Africa, and could play a part in improving the nutritional status of the African.

Work has been carried out during the past ten months on methods of preserving the food value of separated milk on a scale suited to daily intakes of less than 200 gallons. A product containing all the casein in a stable form suitable for transport and storage up to three months at temperatures of less than 75° F. or shorter periods at temperatures of less than 85° F., has been produced by preparing a hard dry cheese. The method of manufacture was a modification of the skim-milk cheese described by Leitch [1].

It is preferable to use a starter, especially if the milk has been produced under primitive conditions. (Starters may be obtained from the author c/o Egerton School of Agriculture, Njoro). After adding the starter the milk is ripened for one hour at 86° F. At altitudes under 7,500 ft. rennet is best added at 88–90° F., and at altitudes over 7,500 ft. at 86° F. The junket is allowed to firm until surface whey appears, when the curd is cut into ¼ in. cubes. These cubes are stirred in the whey for five minutes and then allowed to settle for five minutes and then stirred a second time for 20–30 minutes, during which the temperature of the whole is raised to 92° F. Thirty to forty minutes after cutting the curd is pitched. Half-an-hour later the whey is drawn off. The curd is stirred to remove whey, and then bundled up in cloths holding the equivalent of six gallons of milk for small-scale, or cheddared in the vat in large-scale production.

The curd is cut into two-inch cubes after twenty minutes and the cloth resecured. Twenty minutes later it is torn into pieces by hand or passed through a curd mill, salt being added at the rate of 1 oz. to 3½ lb., and put to press for 36–48 hours. Twenty-four hours after leaving the press the cheese may be waxed; this reduces the risk of mite infection and prevents the cheese drying and cracking.

The resultant product treated as cheese is unpalatable, but used as a basis for stew in place of meat is a valuable adjunct to native diets low in animal protein.

Two of the earlier cheeses were analysed by Dr. Harvey of the Medical Research Laboratory, Nairobi.

	Moisture	Protein (N × 6·38)	Calcium (Ca)
A ..	54·55	36·84	0·811
B ..	52·83	36·61	0·949

expressed as grammes per 100 grammes of cheese.

Calcium salts had been added to the milk before rennetting in both these cheese, although these calcium figures are no higher than was to be expected from untreated milk.

Other cheeses made later were drier and more stable but no analytical data are available.

Compare these figures with those given by Sherman [2] for lean hind shank of beef:—

Edible portion ..	Protein 21.9%
As purchased	„ 9.1%

or data on native meat analysed at the Medical Research Laboratory, Nairobi.

Edible portion Silverside	Protein 20.49%

In some experiments the albumin was recovered from the whey by coagulating with heat, and this albumin added to the separated milk of the next day immediately before rennetting. This method was found preferable to attempting to add the albumin to the curd of the same day's cheese at milling. In another set of experiments the whey was heated, the heat-coagulable proteins strained off, and the remaining whey condensed as for mysost to about 50 moisture. At this point the albumin was reincorporated in the whey paste and the whole added to the curd of the next day's cheese at milling. This paste was incorporated imperfectly with the curd; nor was the cheese held in store long enough to determine the effect on its keeping quality. The addition of this paste whose analysis on a 50 per cent moisture basis is approximately: lactose 38 per cent; albumin and globulin 7 per cent; ash 4.5 per cent would not result in an important addition of food required by the African, while it would be expensive to produce and show little advantage over the addition of the heat coagulable proteins alone.

Successful attempts were made on a small scale using 3 per cent of a vegetable oil (groundnut oil) to replace the lost butterfat. A stable emulsion was made using equal parts of oil and separated milk passed through a domestic "cream-maker" and adding this thick cream to the milk before rennetting. Loss of oil in the whey was negligible, and the cheese did not sweat. The ripe cheese had a powerful flavour of groundnut oil which a number of Africans seemed to find pleasing.

Similarly, were it available, red palm oil might be added, and it, by increasing the carotene content would still further improve the food value of the product.

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[1] Leitch, R. H.—*West of Scotland Agricultural College Bull.*, 87, 1918.

[2] Sherman, H. C.—Chemistry of Food and Nutrition, 5th Edition, p. 582.

A METAL-LINED PIT CHARCOAL KILN

By F. Hughes, Forest Department, Tanganyika

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A simple but effective charcoal kiln can be made from the steel bodies of 3-ton and 5-ton military lorries, of which considerable numbers are available from vehicles released by the Army Disposals.

CONSTRUCTION OF THE KILN

Any projections inside the body, such as seats or tool boxes, are removed. At one end three circular holes, each six inches in diameter, are cut in the floor, one at each corner and one in the middle. The top edges of both ends are notched with a hacksaw to take two iron bars (light rails) running the length of the kiln. The body is then sunk in a pit until the top edge is at ground level. Three flues constructed from 1/16th inch sheet iron, six inches in diameter, are then inserted at the end of the kiln to connect with the three holes cut in the floor. (*See diagram overleaf.*)

OPERATION

The kiln is filled with billets of wood which are placed along the length. Sizes up to twelve inches in diameter can be taken if the wood is dry. With green wood it is not advisable to use sizes greater than nine inches. The smaller billets are placed at the bottom and the larger ones at the top of the charge and towards the flue end. At the end opposite to the flues a space of about nine inches is left free of billets. When the kiln is full, corrugated iron sheets are placed over it, leaving a gap of about nine inches at both ends. A fire is then lit in the space left at the end away from the flues. This is fed with dry fuel until a hot bed of coals is formed at the bottom of the kiln and the ends of the billets forming the charge are well alight. The space is then filled with billets and closed with a sheet of corrugated iron. The gap at the flue end of the kiln is reduced to about half an inch and a sheet of corrugated iron is placed on its edge between the end of the kiln and the entrances of the flues. The corrugated iron sheets are held down with iron rails or heavy pieces of firewood and the edges sealed with earth to prevent escape of smoke. Air is drawn in through the flues, along the bottom of the kiln to the fire, and smoke escapes along the top of the kiln through the half inch gap left at the flue end. Carbonization proceeds from the ignition and towards the flues and is complete when white smoke ceases to issue from the gap and red hot charcoal can be seen there. This may take up to twenty hours and when completed the half inch gap is closed and sealed with earth. The flues are covered with 4-gallon petrol tins and sealed. Two or three days are required for cooling.

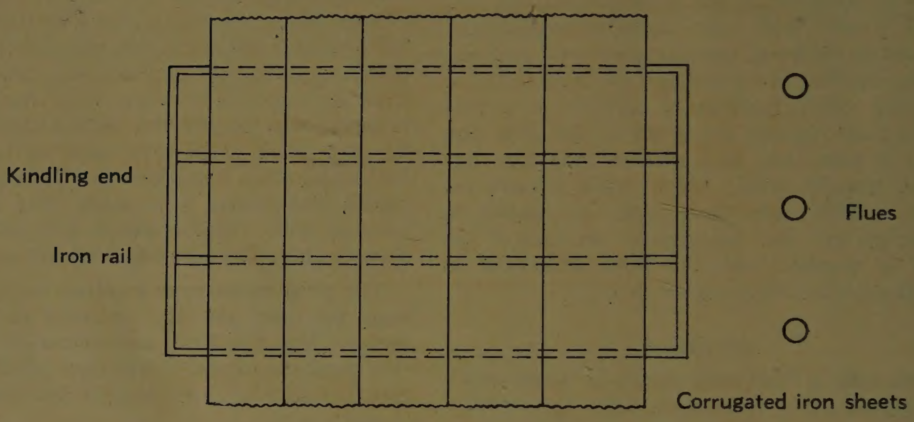
The yield varies from eighteen to twenty-five bags per run and the charcoal is of good quality. It is free from contamination by earth (the great drawback of ordinary pit kilns) and can therefore be easily bagged with a fork and shovel.

TIMING OF OPERATIONS

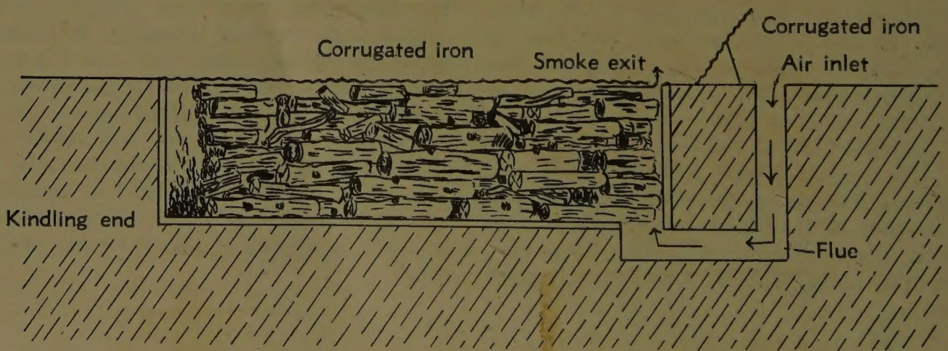
The charge should be lit at 2 p.m. Up to two hours are allowed for lighting and warming up, and by 4 p.m. the gap above the fire is closed. The kiln should then burn with no attention until 6 a.m. the next morning. It should be ready for closing down between 6 a.m. and 12 a.m. Three nights should be allowed for cooling and the kiln opened up early in the morning, to be refilled for lighting up again at 2 p.m. The whole cycle requires four days, and it is therefore economical to operate the kilns in batteries of four, which would give an average output of about twenty bags per day.

A METAL-LINED PIT CHARCOAL KILN

TOP VIEW OF KILN SHOWING ARRANGEMENT OF CORRUGATED IRON SHEETS DURING WARMING UP PERIOD



SIDE VIEW WHILST BURNING IN PROGRESS



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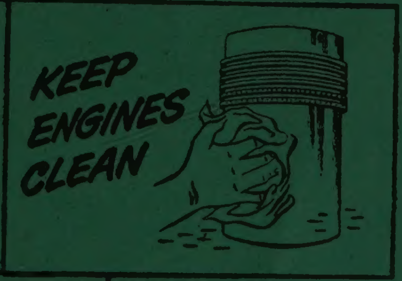

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